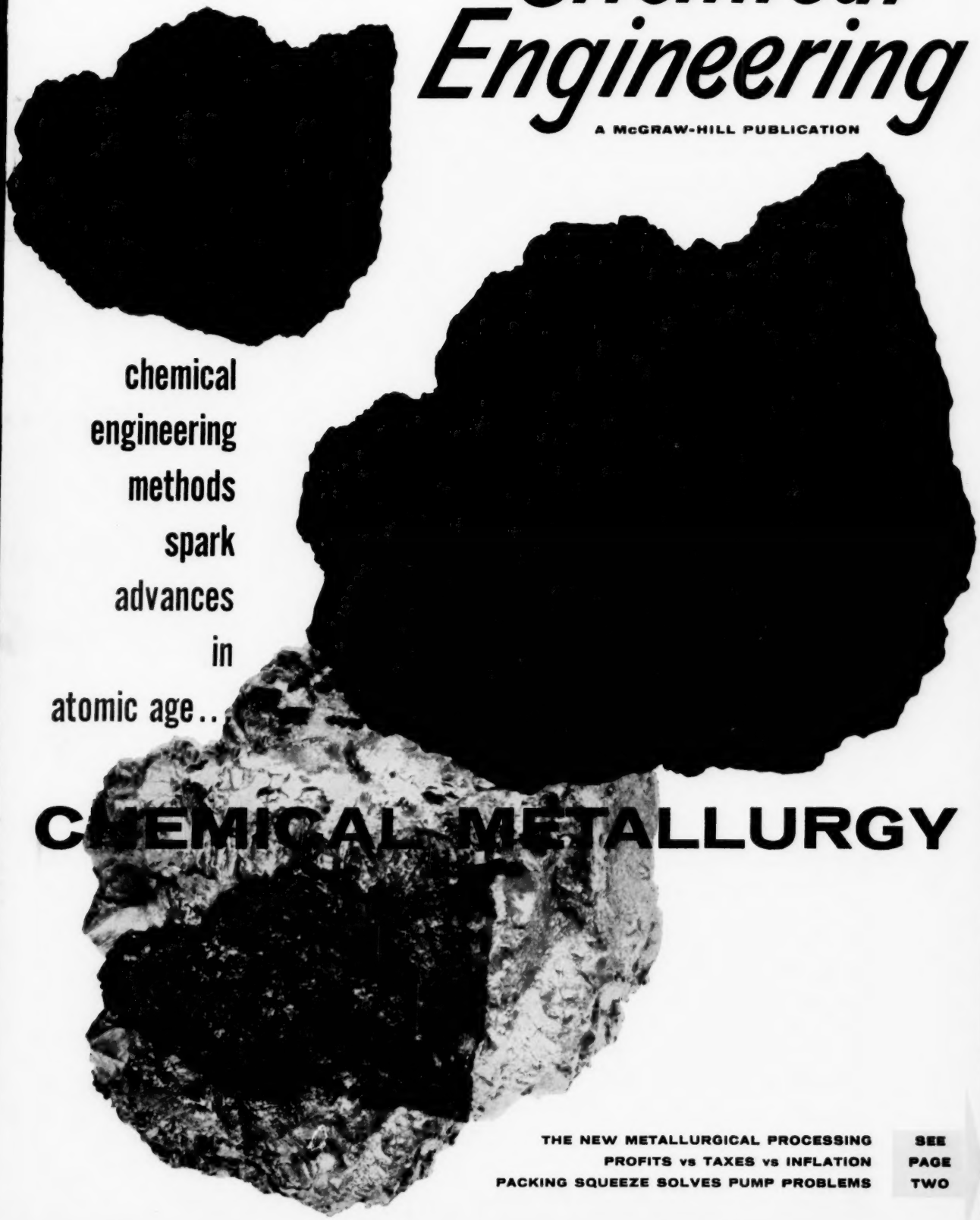
JANUARY 27, 1958
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION



chemical engineering methods spark advances in atomic age...

CHEMICAL METALLURGY

EAK . . . a high-boiling solvent with a future

In formulations for surface coatings, ethyl amyl ketone complements low-boiling MEK and medium-boiling MIBK by promoting better flow and gloss and eliminating dry overspray.

EAK possesses excellent blush resistance, good diluent tolerance and high solvency for surface coating materials. Its slow evaporation rate contributes to excellent flow-out, tends to minimize pinholing and bubbling in the film.

EAK has proved to be a valuable component of thinners for various types of coatings such as automotive refinishing lacquers, silk-screen printing lacquers and multicolor lacquers. Cellulose esters, vinyl polymers and copolymers, and almost all synthetic and natural resins are soluble in EAK.

Your Shell Chemical representative will be glad to discuss your specific solvent needs with you. Write for Organic Chemicals, a catalog of Shell solvents, resins and intermediates.

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JANUARY 27, 1958

JOHN R. CALLAHAM, Editor-in-Chief

Help Us Help You

Most of you know by this time that we've stepped up CE's publishing frequency to 26 times a year . . . a major step forward in the 55-year history of this publication.

Now that you've had a chance to digest two issues of your "new" CE (this is your second issue), why not take a few minutes to help us help you?

You can do this simply by letting us know your reactions to the job we're doing and how you'd like to see us do it better. Both brickbats and bouquets—please don't spare either—alert us to your needs, keep us on our editorial toes.

A short letter, note, postcard or phone call will do the trick.

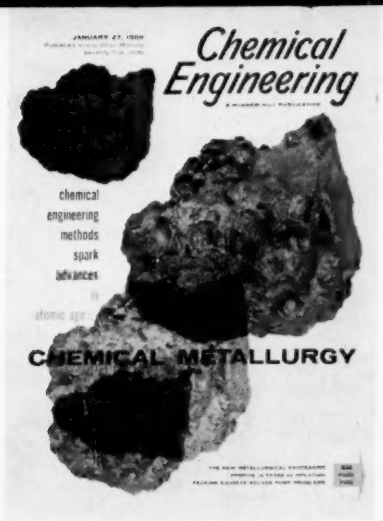
Skeptical? Well, just mentally multiply your own note several thousandfold. That'll give you an idea of how impressed we'll be, why we rely on such reader reactions as a clear-cut guide to a better goal.

Thousands of you, of course, already help us in this way by answering the questionnaire we send out every month to a cross-section of 1,000 subscribers.

But why wait three years or more for your name to come up automatically on this rotating list? We'd like to get your ideas *now!*

One more point: Please don't feel slighted if we can't answer you personally. We're mighty busy right now with these biweekly issues, but we do promise to give your comments our serious study and consideration.

By helping us turn out a better CE you're helping yourself as well as over 44,000 other engineers throughout the chemical process industries.



SECOND OF TWENTY-SIX ISSUES

2/26

GUIDED TOUR

Chemical engineers put new life into today's extractive metallurgy

From ore to concentrate—chemical processing has made many metals economically recoverable. Survey of important methods now used or under development emphasizes the contributions of chemical engineers to the new extractive metallurgy. In this wide open field some of the techniques need improvement. Many will prove useful in other processing applications. (p. 107)

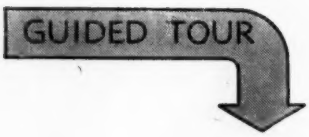
Profits from corn liquor

Novel acid recycle and ion exchange application are wringing a new byproduct from corn steep liquor. Phytic acid in carboy quantities is now available thanks to work on a hitherto untapped source. (p. 61)

Profits vs. taxes vs. inflation

For the first time, relationships are given for taxes, inflation and rate of return.

Chemical



January 27, 1958

They'll let you include the effect of all three factors in your engineering cost comparisons. (p. 123)

Help for your proportioning troubles

Handy factors and equations speed up answers to many kinds of problems in blending, diluting and chemical treating. How to juggle weight units and flow rates into material balance calculations. (p. 129)

The secret of better pump packing

A simple scheme clears away misunderstandings of pump-packing principles. Mere substitution of a spring for the lantern gland will cure most troubles and solve your soft-packing problems. (p. 131)

How (and why) to lead a meeting

On the way up the management ladder you'll have to lead many a meeting. There are 12 "do's" and 6 "don'ts" that you must know. Then you'll handle any situation with conspicuous success. (p. 157)

CE is edited for the engineer concerned with chemical operations, whatever his function . . . administration, production and plant operations, design and construction, research and development, sales and purchasing. More engineers subscribe to CE than to any other magazine in the field. Print order of this issue:

47,175

Developments in Chemical Engineering

Practice of Chemical Engineering

Engineering

Vol. 65, No. 2

Chemical Engineering (with Chemical & Metallurgical Engineering) is published bi-weekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948) Founder. Publication Office: 99-129 North Broadway, Albany 1, N. Y. See panel below for directions regarding subscriptions or change of address.
Executive, Editorial, Circulation and Advertising Offices: 330 West 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice President; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary; Nelson Bond, Executive Vice President, Publications Division; Ralph B. Smith, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator.
Subscription rate in U. S. and Possessions for individuals in the field of the publications $3 per year (Canada $4), single copies 75¢. **Position and company connection must be indicated on subscription orders.** Send to address shown in box below.
Second class mail privileges authorized at Albany, N. Y. Printed in U.S.A. Title registered in U.S. Patent Office.

Subscriptions: Send subscription correspondence and change of address to Subscription Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Subscribers should send notice promptly for change of address, giving old as well as new address, and including postal zone number, if any. Enclose an address label from a recent issue of the magazine if possible. Please allow one month for change to become effective.

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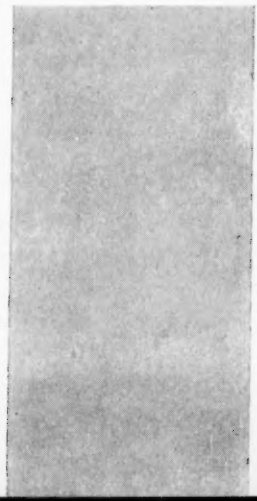
Chemical Engineering

This issue's top features of significance in

Petrochemicals & Petroleum Refining

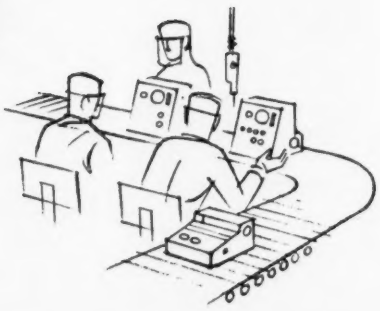
JAN. 27, 1958

Also of Basic Interest



No. 5 of a series

"I got rid of that cold sweat



Kathabar systems control all air dimensions... temperature, humidity and purity"

You will earn maximum profits from an investment in comfort air conditioning if you specify a Kathabar "full-dimensional" system.

All over the country, Kathabar systems have improved labor productivity in hot and soggy weather, reduced absenteeism, and brightened employee morale.

These profits alone have justified the Kathabar equipment, but there are additional benefits which distinguish Kathabar air conditioning from conventional systems:

extra returns

The Kathabar system automatically conditions *all three* vital dimensions of air—temperature, humidity, and purity. Its control of humidity is a feature favored by users, because it eliminates the shock you feel when you enter or leave spaces conditioned by conventional refrigeration.

The system will either dehumidify or humidify.

specify bacteria count

Air purity is important for both comfort and health, and a Kathabar system contributes to each. Its chemical wash removes odors and dirt from the air. Even better, it kills over 97% of airborne micro-organisms. This drastically reduces the exposure of people and products to mischievous bacteria and molds.

With a Kathabar system, you can actually specify the maximum bacteria count you will tolerate in your space!

Dehumidification for comfort in a Kathabar system is usually accomplished with cooling tower or city water. Where refrigeration is included, the Kathabar system gives you top cooling efficiency with surprising savings in tonnage and horsepower. This is because the system handles latent loads with chemical absorption using lower cost water, and frees refrigeration to handle only the sensible loads.

Since dehumidification is direct (by a chemical absorbent) in a Kathabar system, you avoid the costs of overcooling and re-heating.

no carry-over

The absorbent will not vaporize or carry over into the air stream. With routine checking, it will maintain its effectiveness for years without replacement. The germicidal and bactericidal results are not affected by absorbent age or condition, or whether the system is humidifying or dehumidifying.

Be sure to check the Kathabar system if you want the greatest returns on your air conditioning investment.

who uses Kathabar systems

Kathabar systems make profits out of air for these industries:

Atomic Energy	Machining
Breweries	Matches
Cake Mix	Marine
Candy	Meat
Cellophane	Offices
Cellulose	Ordnance
Cereals	Paper
Chemicals	Pharmaceuticals
Coffee	Plastics
Comfort	Printing
Compressors	Rockets
Cookies	Rubber
Electronics	Shellac
Explosives	Sugar
Film	Sanitaryware
Foundries	Testing
Gelatin	Textiles
Glass	Transformers
Glue	Transistors
Gum	Vacuum Tubes
Hospitals	Varnish
Hotels	Waterworks
Lacquer	Wire
Lenses	Yeast

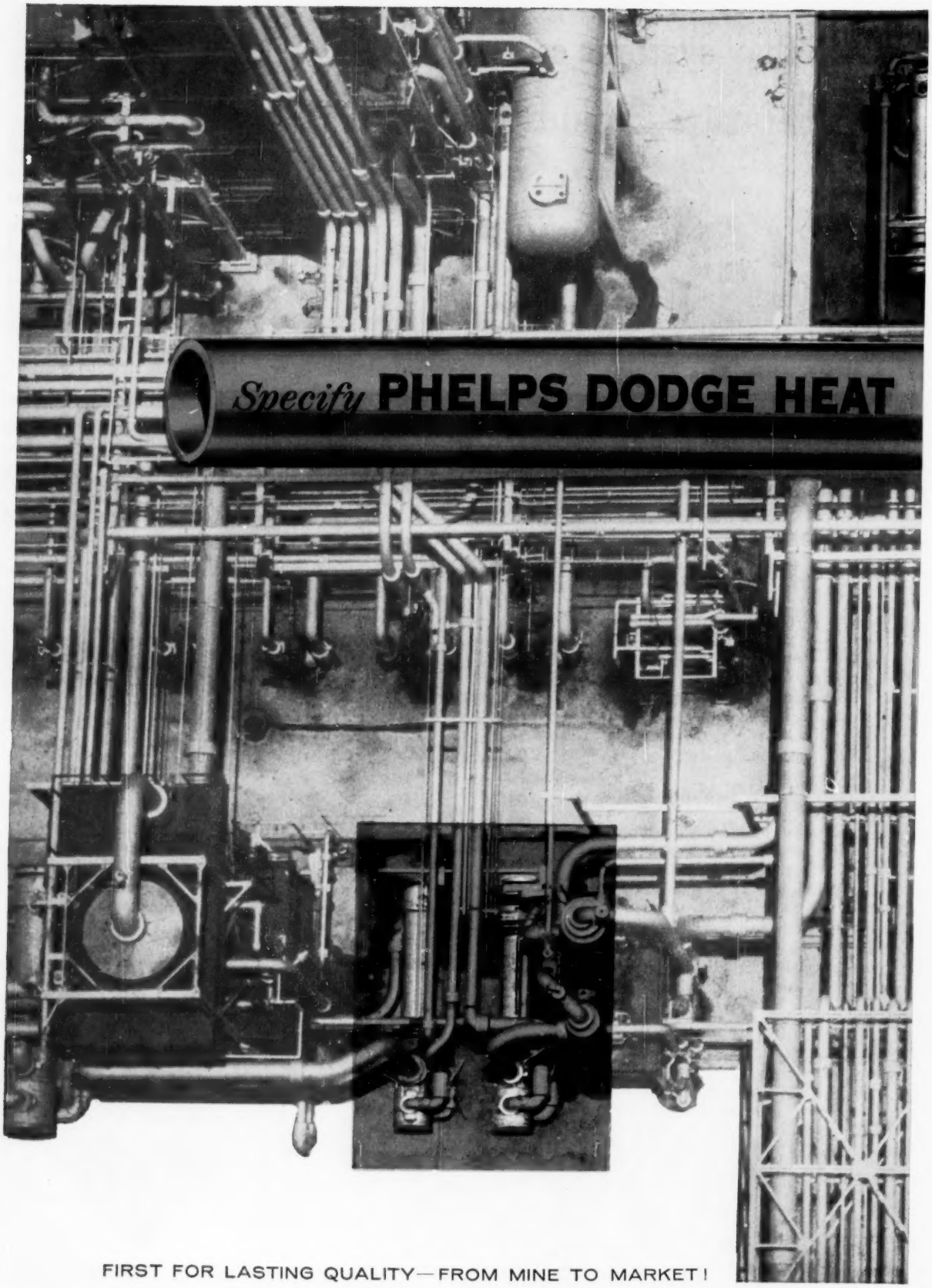
how they use Kathabar systems

Many of these industries use Kathabar systems for comfort. Others use them to (1) maintain spaces at 80 F and 55% RH or lower; (2) obtain continuous air at sub-freezing dry bulbs and dew points; (3) eliminate condensation; (4) improve drying processes; (5) deliver continuous pure air.

send description of your problem

AIR CONDITIONING & DRYING DIVISION
SURFACE COMBUSTION CORPORATION
2380 Dorr Street Toledo 1, Ohio

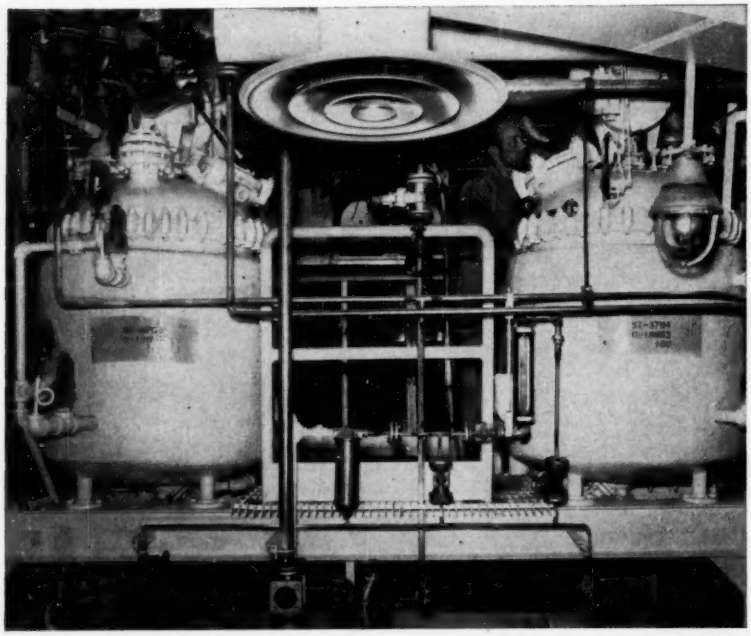
Kathabar systems by Surface



FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

Pfaudler

Pfaudler Corrosioneering News Published by The Pfaudler Co., a division of Pfaudler Permutit Inc., Rochester, N.Y.



Isolating finished steroids is done in these two Pfaudler glassed steel reactors at Merck & Co.'s Cherokee plant. Absolute cleanliness and corrosion resistance are musts here as in all other parts of complex steroid production which involve several highly corrosive acids. See text.

New MERCK Plant a Classic Study in Corrosive Processing

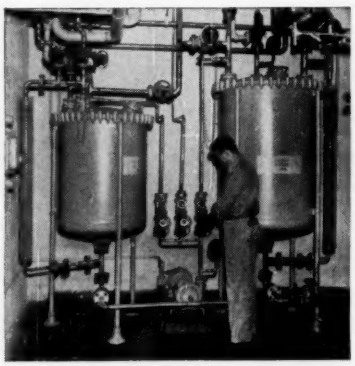
You're putting a new product into production. Serious corrosion problems are involved. You must justify the need for special equipment in terms of profit return on capital investment. Such were the problems met at the new Merck & Co. plant in Danville, Pa.

The plant makes steroids to pharmaceutical grade specifications. Bromine, hydrobromic acid, chlorine and hydrochloric acid, and a series of organic acids are just a few of the corrosive substances that enter into the complex reactions that produce the steroids.

What sort of equipment do you use to produce steroids that satisfy both the quality controllers and the company comptrollers who expect a fair return on their equipment investment?

Experience is the answer

Because of their long, long experience with corrosives, the men at Merck found that the problem spelled out its own answer: Pfaudler glassed steel equipment.



Bromine, Chlorine and their acids are among the biting corrosives handled by these Pfaudler intermediate series kettles at Merck plant. Merck engineers specified Pfaudler without hesitation, basing their confidence on long experience with Pfaudler glassed steel reactors and storage tanks.

Pfaudler glassed steel because this construction material withstands more corrosives than any other — including the halogens and acid halides mentioned above.

Pfaudler glassed steel because it cannot act as a catalyst itself nor will it release trace metals which might trigger treacherous side reactions.

Pfaudler glassed steel because of ease in cleaning and operational longevity—twenty to thirty years of corrosion-free service in many instances.

Pfaudler glassed steel, finally, because of successful experience—our own 73 years of experience and the experience of companies such as Merck to whom "corrosioneering" is a continuous and profitable study.

Four ways to avoid thermal shock damage to glassed steel

We'd be among the last to ask you to *baby* Pfaudler glassed steel, but we do know for fact that *a little tender care* will help your vessels last longer. Tender care such as this:

One. Keep your operating temperatures below 450°F. unless you consult with our engineering department. This limit can be exceeded but it calls for careful study.

Two. Watch your temperature differentials, especially when dumping a cold charge into a hot vessel.

On *standard* vessels up to 2000 gallons, we usually recommend these temperatures:

Reactor temp.	Charge temp. should be at least	Safe temperature differential
250°F.	50°F.	200°F.
300	125	175
350	200	150
400	270	130
450	335	115

When emptying a hot medium into the jacket of a cold reactor, the difference between jacket and reactor temperature should not exceed the "safe" temperature shown above.

Dumping a hot charge into a cold vessel is not as critical, but we recommend a maximum temperature differential of 200°F. throughout the temperature range at which you normally use the equipment.

The same 200°F. differential holds for injecting a cold medium into the jacket of a reactor. Agitating nozzles and their attached baffles help eliminate thermal shock in such cases by

Corrosioneering News

Quick facts about services and equipment available to help you reduce corrosion and processing costs.

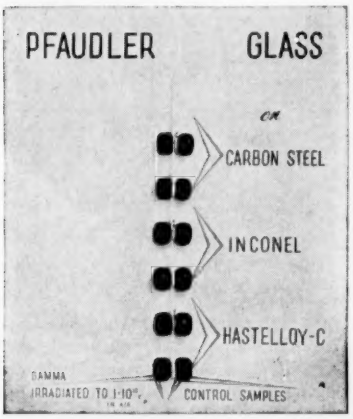
diffusing stream flow and reducing the instantaneous temperature differential.

Three. Be careful when welding or torch cutting. Do not weld to the tank proper under any circumstances. Use electric welding to the jacket, never acetylene. When welding to the jacket sealer, keep at least 2" away from the tank proper. When torch cutting the jacket, cut at an angle to keep flame away from wall of the vessel itself.

Four. Take note of the heat developing from exothermic reactions inside the vessel. Damage to the glass is unlikely unless the reaction gets completely out of hand. For safest operation, however, we recommend that the 200°F. differential be maintained.

Corrosion resistance of glassed steel unimpaired by gamma radiation

No adverse effects could be detected from the exposure of glassed steel to gamma radiation in tests recently completed by Pfaudler in cooperation with Oak Ridge National Laboratory and other installations.



Preliminary evaluations have been completed on the test which exposed glassed samples to a total dose of 10^{10} roentgen from spent fuel elements.

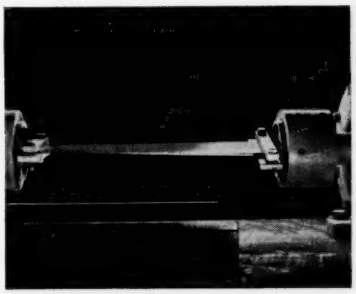
Glassed steel is being considered as a construction material for chemical processing involving nuclear energy wherever corrosive conditions are particularly severe and ease of decontamination is important.

Probable uses of glassed steel in this vast field include storage of acids and other materials which may or may not be radioactive, storage and

continued middle next column

How strong is glassed steel?

We twisted this piece of glassed steel a full 14°, stressing it beyond the elastic limit of the steel itself. Yet the glass-to-steel bond and the glass itself remained intact . . . 100% intact.



This test would satisfy little more than our innate curiosity except for the fact that structural strength *is*

continued top next column

disposal of radioactive wastes, and chemical processing of highly radioactive and corrosive materials.

Both mechanical and corrosion tests indicate that Pfaudler glass is unaffected by gamma radiation up to 10^{10} r, although a color change does occur. Base metals used included carbon steel, Hastelloy C, and Inconel. The corrosion resistance of the glass did not change with the various base metals employed.

A larger test program is now under way to follow up these early results and to determine more conclusively the effect of radiation on glassed metals.

important in the vessels you buy from Pfaudler.

Why such strength? Three reasons —(1) When the glass and steel are fired at high temperature, the molten glass chemically *etches* the steel, resulting in a powerful chemical and mechanical bond. (2) The compressive forces within the cooled glass toughen the glass and provide a cushion for mechanical and thermal shocks. (3) The "bracing" of the glass by its steel backing.

Now... a glassed pump!

Take a Goulds centrifugal pump and glass its entire interior surfacing and you have a workhorse that assures years of corrosion-free operation at low cost.

The Goulds-Pfaudler pump offers high corrosion resistance to all the common acids except hydrofluoric and mild alkalies.

Write to Goulds Pumps, Inc., Seneca Falls, N. Y., for descriptive bulletin.

THE PFAUDLER CO., a division of PFAUDLER PERMUTIT INC.,
Dept. CE-18 , Rochester 3, N.Y.

Please send me: ☐ Bulletin 955, Installation of glassed steel reactors; ☐ Bulletin 947, Buyer's Guide; ☐ Bulletin 892, Structural Strength of glassed steel.

Name.....

Title.....

Company.....

Address.....

City..... Zone..... State.....

as seamless as her best hose...

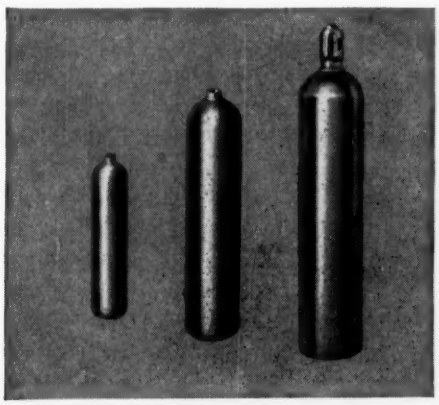
Super smooth and lightweight, Hackney cylinders cut handling costs

Hackney's special Deep Drawing process eliminates unnecessary cylinder weight and smooths cylinder surfaces.

That's why these versatile cylinders are used to ship and store many compressed gases at greater savings. Designed for compact neatness and built strong, Hackney cylinders are precision-controlled to meet your specifications.

See how many Hackney cylinders are used in today's industries—for medicinal gases, for flame cutting systems, for power actuators in the automotive and aviation fields, for mining inhalators, for fire extinguishers—in fact, wherever safety, dependability and economy are needed in a cylinder.

Write for specification sheets and see how Hackney seamless cylinders can boost efficiency in your operation.



Besides seamless cylinders, Hackney also produces a complete line of larger two-piece cylinders—all easy to handle, with low tare weight to save shipping dollars on every trip out and back.

Pressed Steel Tank Company

Manufacturer of Hackney Products

1447 South 66th Street, Milwaukee 14, Wisconsin

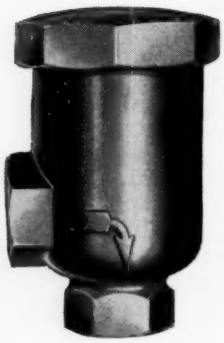
Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

need steam traps?

name the way you want them!

TYPE A



TYPE D

TYPE C

Nicholson can supply your steam traps, exactly as you want them . . . for any service, any condition. Name the size, material, pressure, capacity you need. Types A, D, C are the ones you'll most likely use. Make your selection.

Sizes: A—from ¼" to 1". D—from ¼" to ¾". C—from ½" to 2".

Materials: Cast Iron and Cast Steel.

Pressures: A and D—Vacuum to 200 lbs. C—Vacuum to 300 lbs.

Capacities: From two to six times greater orifice area and capacity than other traps of comparable size.

Why wonder about your steam traps . . . when you can get Nicholsons exactly as you need them for your own applications. Nicholson traps are simple in design, have only one moving part . . . a valve that discharges condensate and prevents steam loss.

You get faster warmup, with high air-venting capacity. You eliminate costly leakage, with a powerful shut-tight valve action. You get a trap that's service-tested, when you specify Nicholson. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and engineering offices in 98 principal cities.

NICHOLSON

of Wilkes-Barre

Passes acid test—by more than 3 times

Unloading carloads of concentrated sulphuric acid proved a hose-killing job at this Gulf state fertilizer plant. Time after time, the acid charred the insides of a hose, making it brittle and easy to break. Even the best one could handle only 2,800 tons before it gave up the ghost.

Then the G.T.M.—Goodyear Technical Man—suggested HYSUNITE Hose. It's specially developed to carry highly oxidizing acids—even in high concentrations and at high temperatures hose could never before handle. How did HYSUNITE do there? *At last report, it had unloaded 9,900 tons. And it looks good for many more.*

Here's one more proof, then, that hose problems just don't come too tough for the G.T.M. Put him to the acid tests—no matter what your hose need—by contacting your Goodyear Distributor—or writing:

Goodyear, Industrial Products Division,
Akron 16, Ohio

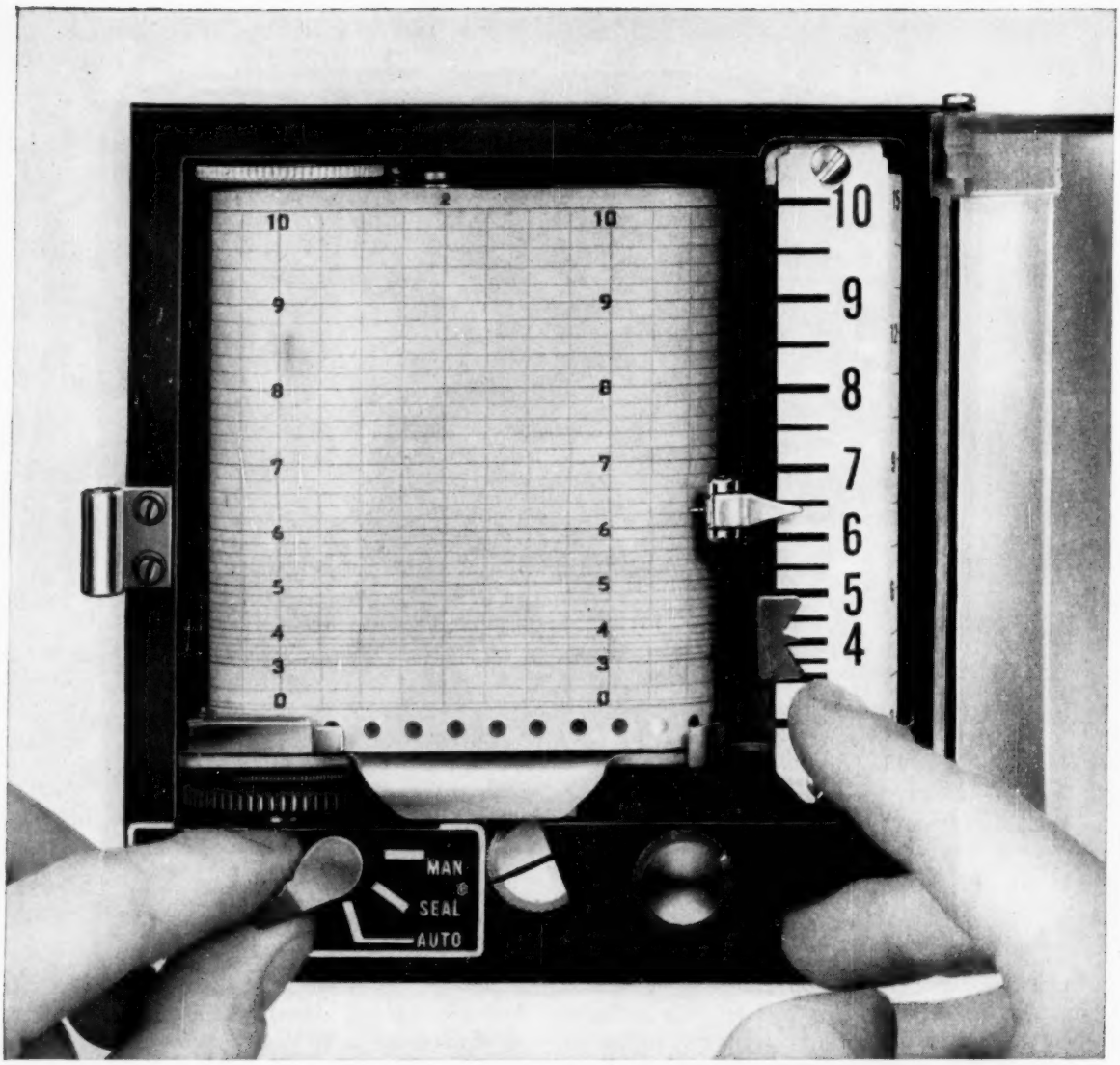
HYSUNITE HOSE by

GOODYEAR

THE GREATEST NAME IN RUBBER

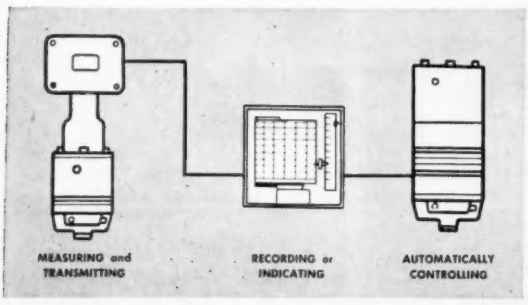
Hysunite—T.M. The Goodyear Tire & Rubber Company, Akron, Ohio

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

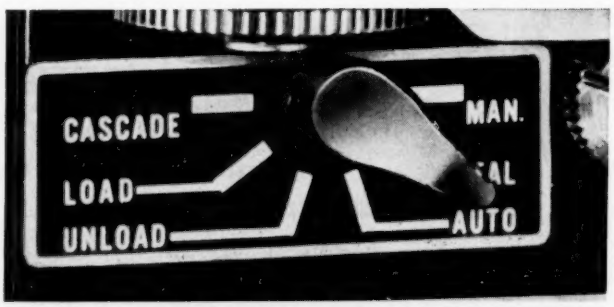


BRISTOL METAGRAPHIC RECEIVERS:

"Easiest 'bumpless



BRISTOL METAGRAPHIC INSTRUMENT SYSTEM

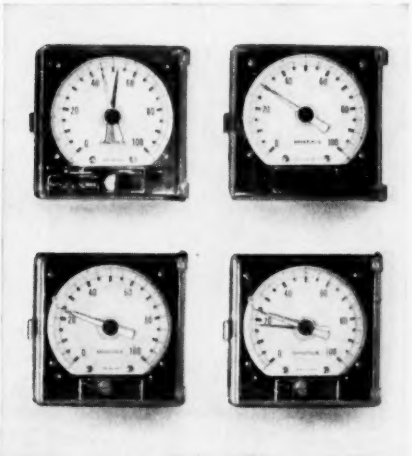


SIX-POSITION SINGLE-KNOB TRANSFER STATION (enlarged view) for cascade service. Three-position manual-automatic station is also available.

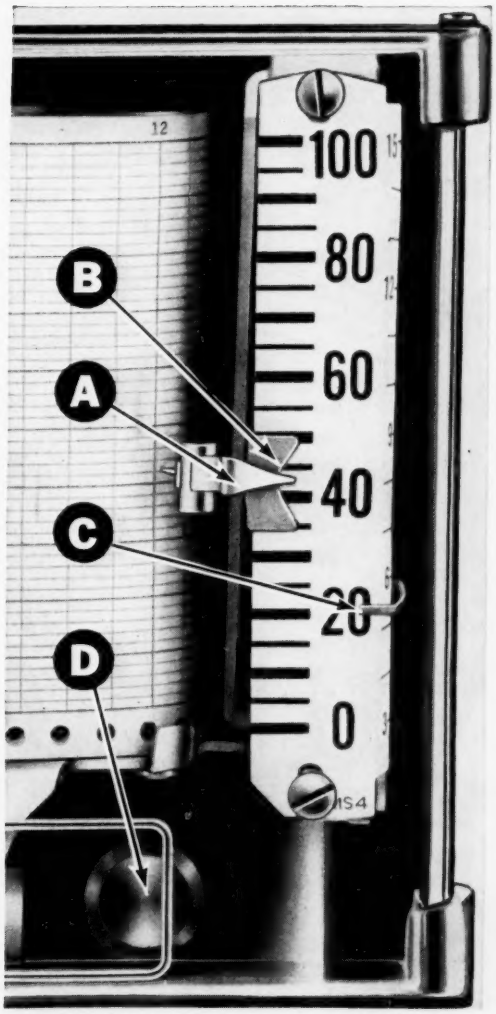
ONE OF 38 METAGRAPHIC RECEIVER MODELS you can choose from, all with 5" x 5⅛" panel, all fitting into same 4 9/16" square panel cut-out. This Metagraphic Recording Receiver has single-knob six-position transfer station, gives easy start up and initial adjustment and completely "bumpless transfer" in complex cascaded control systems. Single-knob, six-position transfer station lets you select:

1. Completely automatic-cascade operation.
2. Automatic operation of slave loop alone.
3. Manual operation.

You get "bumpless transfer" both ways between all three conditions. This convenient switching greatly facilitates start-up of cascaded systems and initial adjustment of slave controller proportional, reset, and derivative actions.



METAGRAPHIC INDICATING RECEIVERS have full 9-inch scale for easy reading; feature: Complete 10-second interchangeability with recorders, show valve position as well as set point and controlled variable. Highly visible fluorescent paint on pointers makes deviation of set point and variable instantly apparent from as far as 20 feet away.



METAGRAPHIC RECEIVER shows measured variable (A), set point (B), and valve position (C), all on same scale. That's what makes manual-automatic transfer so easy, bumpless, and error-free with this instrument . . . just seal, match pointers with knob (D), transfer—that's all there is to it.

transfer' you ever saw"

That's what instrument men say after trying the Bristol Metagraphic Pneumatic Receiver—even in complex cascade control systems.

Just seal, match pointers, transfer. There's not a single value to read. It's that easy because the Metagraphic receiver gives you one-knob control plus continuous valve position indication on the same scale with set point and measured variable.

A genuine plug-in receiver. The Metagraphic is a *true* plug-in receiver—no finger-disconnects. *It plugs and unplugs in 5 seconds with no loss of automatic control. The case acts as a blind controller while the receiver is out.*

Don't pay for pre-installation errors. The Metagraphic's full plug-in versatility lets you switch from indicator to recorder in less than 10 seconds, interchange many receiver models, change recorder range simply by changing chart. Cuts down on costly reinstallations if process requirements are changed.

Write for the complete story on Bristol Metagraphic Receivers. Bristol gives you the widest selection of plug-in miniatures on the market—pneumatic, telemetering, electronic. (Full-sized instruments, too.) The Bristol Company, 109 Bristol Road, Waterbury 20, Conn. 7.33

BRISTOL *TRAIL-BLAZERS IN PROCESS INSTRUMENTATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

The Foxboro M/58 Consotrol Controller (shown full size, without cover). Can be panel-mounted on Consotrol Control Station, or field-mounted.

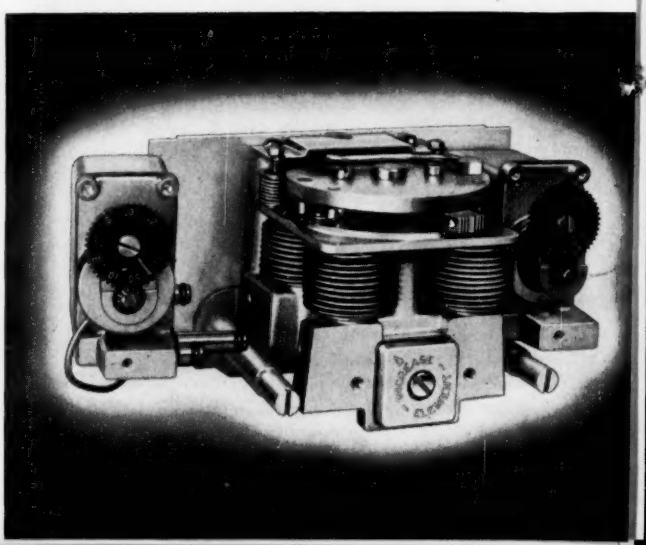
THE FOXBORO M/58 CONSOTROL

The M/58 Controller's Revolutionary Floating Disc System

Here's the exclusive Foxboro design development that gives M/58 Control its unique versatility, precision, and stability. The floating disc and matched bellows assure uniformly high controller sensitivity and pin-point control action, even at widest settings of the proportional band. Lever-set proportional band adjustment is calibrated to 500%.

Component Construction Gives Unrivaled Versatility

Not only is the complete controller easily detachable as a unit, but also, each component is a "plug-in" unit. For example, reset plugs in at right as shown; derivative, similarly, at left. All 4 control actions, with 2 reset ranges, are available and easily adjustable to widest variations in operating conditions. Proportional action from 1 to 500% quickly set by lever.



Outperforms all other controllers!

...the controller with the FLOATING DISC

If you think this claim is exaggerated, just put a Foxboro M/58 Consotrol* Controller on your process. The tougher the job, the more it will outperform other controllers! Or ask any present user . . . many of the largest, most progressive petroleum and chemical processors are using hundreds of these instruments. They will unhesitatingly confirm that this exclusive Foxboro development has put their processes "on stream", automatically and smoothly from the control room, without false starts or confusion.

The M/58 Controller can do the same for your process. The flexibility of its control functions makes it readily adaptable to *all* processing techniques. All four actions are available, with two ranges of reset . . . all are easily adjustable to the most widely varying operating conditions. For example, reset and derivative functions plug in . . . proportional action from 1 to 500% can be quickly set by a lever. And calibration is a simple zero adjustment!

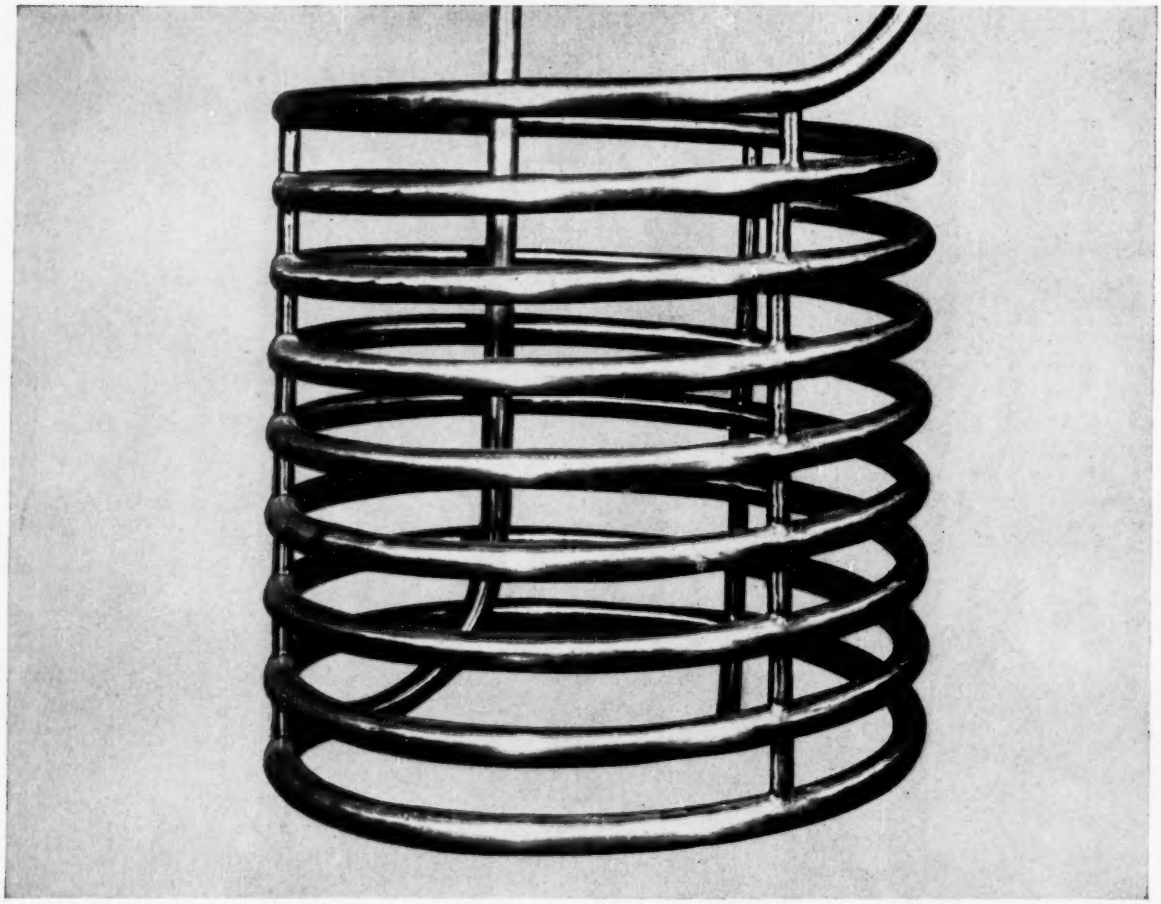
Get full details on this simple, truly "universal" Controller. Write for Bulletin 13-19 and ask your Foxboro Field Engineer for a demonstration. **The Foxboro Company, 361 Neponset Ave., Foxboro, Mass., U.S.A.**

*Reg. U.S. Pat. Off.

FOXBORO
Reg. U.S. Pat. Off.

CONSOTROL INSTRUMENTS

TITANIUM—available now for long service



This titanium heating coil is expected to give 5 years' trouble-free service handling a 12% sulfuric acid-bearing solution at atmospheric pressure.

Titanium coil heats sulfuric acid solution in presence of metallic sulfates

• LASTS 66% LONGER THAN SILVER
• CUTS OPERATING COSTS* BY 35%

Stress corrosion cracking limited the service life of a silver heating coil to 3 years. Maintenance was frequent and costly. The environment, a 12% sulfuric acid-bearing solution containing metallic sulfates, proved to be one in which titanium excelled. A titanium coil was installed... investigation after 9 months showed no pitting or cracking. Based on this performance, the estimated service life of this coil is 5 years, or 66% longer... with savings of 35% in operating costs.

**Includes repair labor, replacement materials and depreciation.*

life . . . corrosion resistance . . . economy in use

Proven economies

Titanium is actually the *least expensive* metal you can use under many corrosive influences. It withstands conditions that reduce the service life of ordinary and high-alloy metals . . . cuts downtime and replacements.

Titanium offers the economy of long, trouble-free service when exposed to such corrosive environments as:

Salt Water
Marine Atmospheres
Nitric Acid
Wet Chlorine
Chlorinated Organic Compounds
Most Inorganic Chloride Solutions
Molten Sulfur
Chromic Acid
Aqua Regia
Hypochlorites & Chlorine Dioxide

TITANIUM—available today

Titanium is now readily available for non-defense applications. Standard parts of titanium are already solving severe corrosion problems in the chemical, food, pulp, paper and allied industries.

In your process development work, take advantage of the corrosion and cavitation resistance, light weight and high strength of titanium . . . important considerations for continuous flow, high temperature and pressure processes.

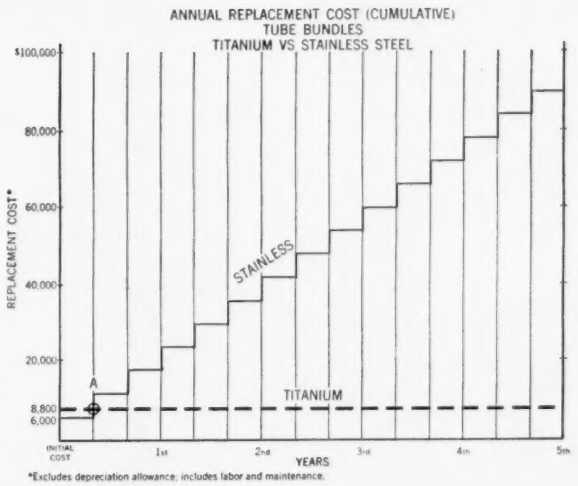
As a manufacturer and pioneer producer of titanium sponge, Du Pont has been working with leading mill-products producers and process-equipment manufacturers on the commercial development of titanium. This broad experience can be applied to *your* corrosion problems. Just get in touch with Du Pont for further information.

Be sure to mail the coupon below for an informative booklet about titanium—its properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Titanium Market Development Section, Wilmington 98, Delaware. (This offer is limited to the United States and Canada.)

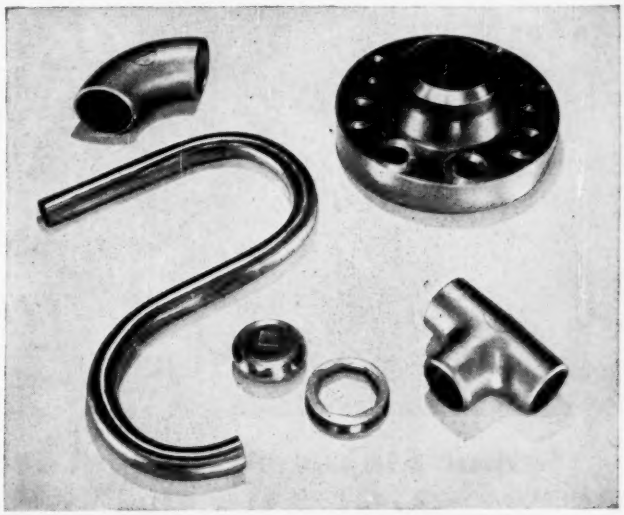
PIGMENTS DEPARTMENT

DU PONT
REG. U.S. PAT. OFF.

LETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



ANOTHER INSTANCE of titanium's long life is shown by this cost/service graph comparing titanium vs. stainless condenser tubes handling 60% nitric acid. Titanium tube bundle costs $8,800 vs. $6,000 for same unit in stainless. The $2,800 difference is absorbed within 4 months of service. Based on service life of 10 years, titanium will save at least $162,000 maintenance and replacement costs.



NOW AVAILABLE. Titanium parts and fittings like this tee joint, 90° weld ell, welding neck flange, pipe bend and powder metallurgy valve trim are just a few examples of standard commercial items now made of titanium.

Pioneer producer of TITANIUM SPONGE

Please send me more information on titanium. I am interested in evaluating titanium for these applications:

_____

_____

_____

E. I. du Pont de Nemours & Co. (Inc.)
Titanium N-2496, CE-2, Wilmington 98, Delaware

*Name*_____ *Title*_____

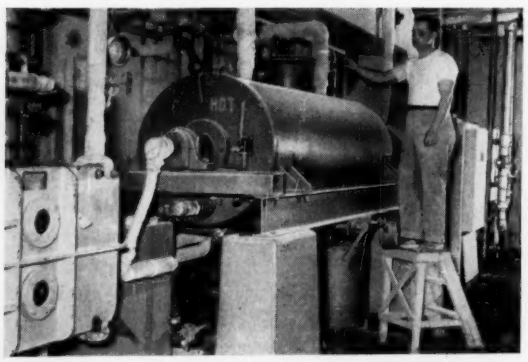
*Firm*_____

*Address*_____

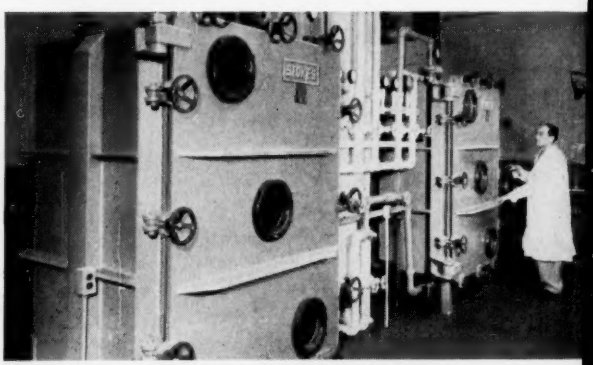
*City*_____ *Zone*____ *State*_____

Two Stokes Model 214 Double Drum Dryers installed at Penick and Ford, Ltd., Inc., Cedar Rapids, Iowa, for starch production.

other Stokes equipment for chemical processing



Rotary vacuum dryers provide fast, thorough, uniform and economical drying of large batches. Heat is provided through the jacketed shell, and agitation through a double-spiral blade. Vapor can be condensed for solvent recovery. Stokes rotary vacuum dryers are available in a broad range of sizes.



Vacuum shelf dryers are ideal for drying materials that are sensitive to heat and oxidation, and which cannot be agitated. Shelves can be heated by steam, hot water or hot oil. Solvents can be recovered. New Model 238 Line features all-welded steel construction, ASME code certification and full outside manifold connections.

There is a difference ...in Drum Dryers

Your needs dictated the features that are built into Stokes Drum Dryers to give you highest quantity and quality drying performance.

There's more to good drum drying than a heated drum, a drive and a doctor knife. How these elements are designed and utilized can mean the difference between a reliable, profitable process and one that is a headache. The standard "extra" design and construction features of Stokes Drum Dryers give you continuous operation that means no maintenance shutdowns, process uniformity that means more pounds of saleable product, operating efficiency that means greater net profit.

Look at these "extra" features that are "standard" on Stokes equipment.

Steel drums, chromium-plated . . . give high dimensional stability for uniform, maximum production, greater operating safety. Shell rigidity minimizes deflection under reduced pressure operation.

Rigid doctor assembly . . . applies uniform pressure on flexible blade, insuring complete product removal with minimum blade wear.

3-point end-dam adjustment . . . helps eliminate deflection and minimize leakage, keeps power consumption down.

Totally-enclosed end frames . . . guard against gear wear and improve housekeeping.

Lateral drum adjustment . . . assures correct edge alignment, minimizes end-dam wear and leakage, prevents costly mis-alignments.

Anti-friction roller bearings . . . mean minimum power consumption, uniform drum alignment.

Compact, variable-speed drive . . . assures maximum power efficiency.

Stokes Drum Dryers are available in both single and double drum types, in a number of standard sizes. Special sizes are supplied to your specifications.

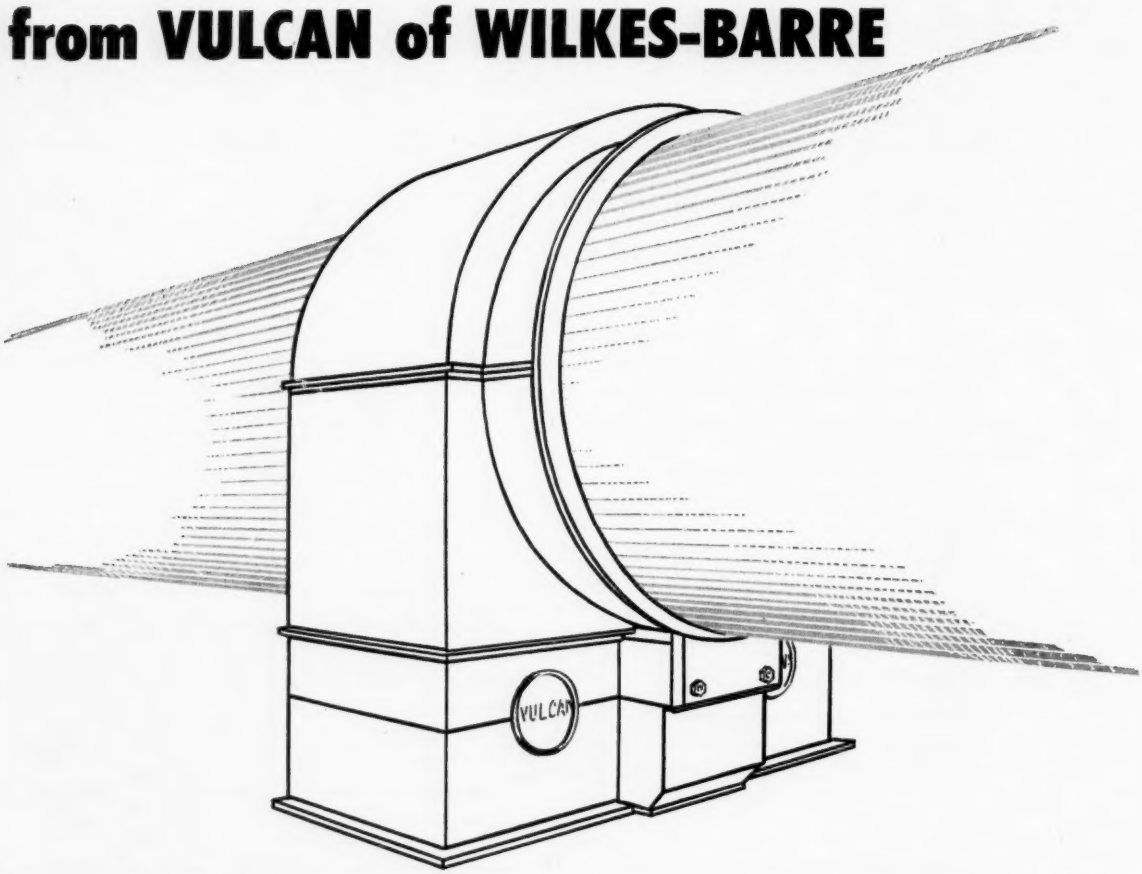
Stokes also produces a broad line of other quality equipment for the chemical and processing industries . . . and maintains a complete laboratory to provide you with expert application assistance. For complete information, write to Stokes or contact your nearest Stokes office.

Vacuum freeze dryers preserve potency in many heat-sensitive pharmaceutical, chemical and food products through drying by sublimation. Dried materials can be stored indefinitely under varying conditions, and are readily reconstituted for immediate use. Sizes for laboratory, pilot plant and production.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

THIS IS THE "NEW LOOK" IN ROTARY KILNS (FOR ALL APPLICATIONS) from VULCAN of WILKES-BARRE



This is the packaged power unit of VULCAN's new concept in Rotary Kiln Design. The rollers that support the kiln, the girth gear, and gear train that power it, and a positive thrust mechanism have been integrated in a sealed enclosure.

This integration not only saves one concrete foundation pier but enables VULCAN to gear link these integrated units for positive synchronous rotation. This is an entirely new concept in Rotary Kiln design that will: simplify your foundation plan; avoid frictional wear; reduce torque and power load; save maintenance costs; occasion less down time . . . and give you a trouble-free mechanical unit for inclusion in any plan of automation for any industrial process in which a Rotary Kiln is employed.

This big forward step in Kiln design should be right in step with your expansion or remodeling program.

Write today for full particulars. Estimates, constructive suggestions and preliminary drawings will be furnished (as far as possible) without obligation. VULCAN brings you 107 years of experience in Kiln design and manufacture.

VULCAN IRON WORKS

WILKES-BARRE PENNSYLVANIA

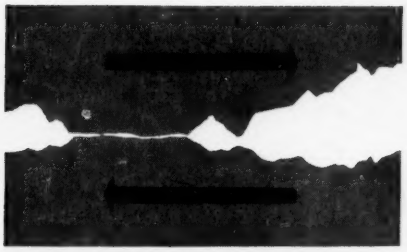
"THE OLDEST NAME IN ROTARY KILNS"

ESTABLISHED 1849 • CABLE ADDRESS: VULWORKS

WHY VALVE LUBRICATION SAVES MONEY

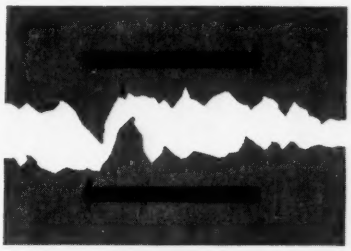
TROUBLE STARTS WHEN METAL RUBS METAL...

Under the microscope, metal that appears mirror-smooth to the naked eye shows as sharp mountains and deep valleys. This roughness, combined with the heat and pressure of metal-to-metal rubbing, causes valve trouble in the following ways:



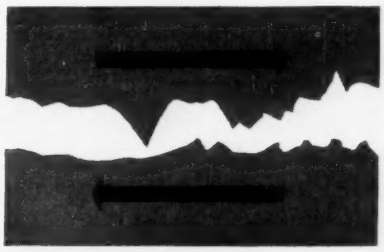
STICKING

"Cold Welding" occurs when friction or pressure welds the peaks together. The result: sticking.



SHEARING

The "hills" of one surface gouge into the hills of the other surface causing further sticking and scoring.

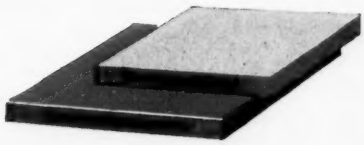


PLOWING

If one surface is even slightly harder than the other, the hard peaks act like a "plow". Leakage soon results.

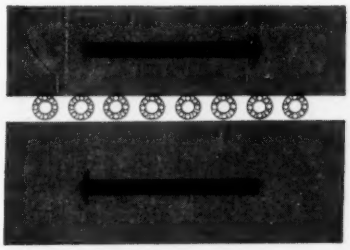
BUT, WITH ROCKWELL-NORDSTROM VALVE LUBRICATION...

metal-to-metal contact is eliminated. Here's what happens when metal-to-metal surfaces are lubricated:



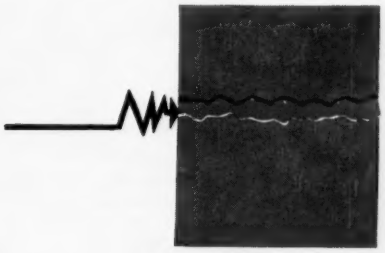
SLIDING

Lubricant prevents friction heat, eliminating danger of cold welding and assuring easy movement.



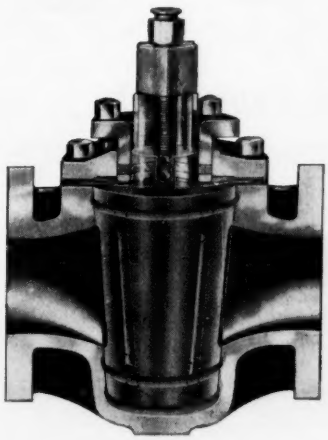
ROLLING

Lubricant becomes millions of tiny bearings . . . metal surfaces actually never come into contact with one another.



SEALING

Pressurized lubricant forms an impenetrable, continuous seal against leakage.



LONGER LIFE, LOWER COST, better valve service results when you specify Rockwell-Nordstrom lubricated plug valves. Notice in the drawing at the left how lubricant protects all the working surfaces and seals positively against leakage. Since lubricant eliminates adhesion, shearing and plowing, Rockwell-Nordstrom valves cost you less to use . . . year after year. Rockwell-Nordstrom valves are available in a complete range of sizes and pressure ratings to answer every flow control need. They cost no more to buy, often less, than ordinary valves. See your nearest supplier or write Rockwell Manufacturing Company, Pittsburgh 8, Pa. for complete details.

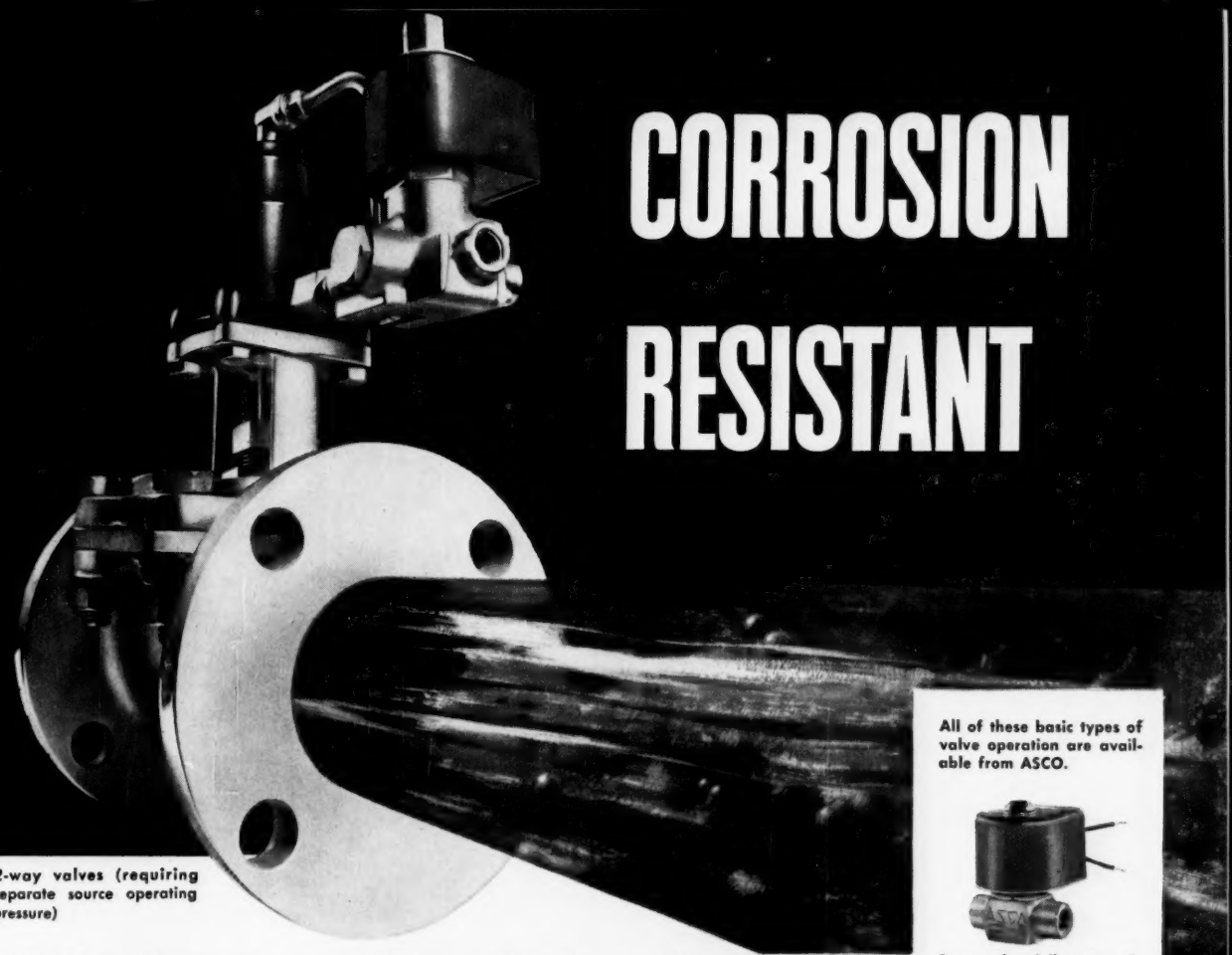
Canadian Valve Licensee: Peacock Brothers Limited

ROCKWELL-Nordstrom VALVES

it's **ROCKWELL**

MANUFACTURING COMPANY

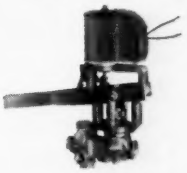
CORROSION RESISTANT



2-way valves (requiring separate source operating pressure)

All of these basic types of valve operation are available from ASCO.

2-way valves fully automatic (do not require separate source operating pressure)



2-way and 3-way Manual Reset

3-way Fully Automatic

ASCO offers a complete selection of corrosion-resistant 2 and 3-way solenoid valves

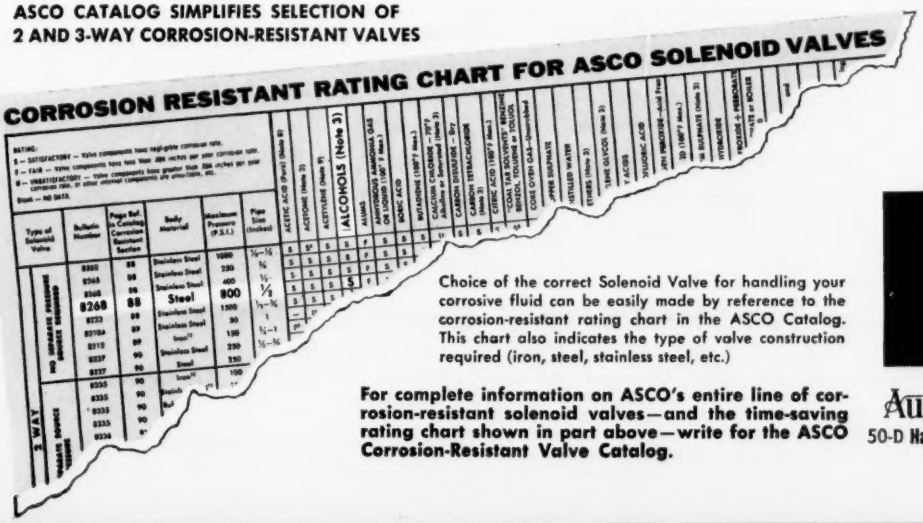
ASCO is the single source for a complete selection of Solenoid Valves capable of controlling corrosive gases and liquids.

Fully automatic or manual reset 2 and 3-way valves are available; 2-way valves can be obtained which are suitable for operating with or without a separate pressure source. Pipe sizes range from 1/8" to 6"; pressures to 1500 PSI, temperatures to 600°F. Catalog listed body materials include, for example, cast iron (with nickel alloy trim), cast steel (with stainless steel trim), stainless steel and monel – with rubber or glass linings. Many other types of body and trim material are available – or special valves can be designed to your specific application. All valves are available with standard, watertight or explosion proof solenoid enclosures, to meet any installation requirement.

Fluids handled range from sulfuric acid to sodium hydroxide – and include a variety of materials such as vegetable oils, distilled water, acetylene, coke oven gas, etc.

ASCO CATALOG SIMPLIFIES SELECTION OF 2 AND 3-WAY CORROSION-RESISTANT VALVES

CORROSION RESISTANT RATING CHART FOR ASCO SOLENOID VALVES



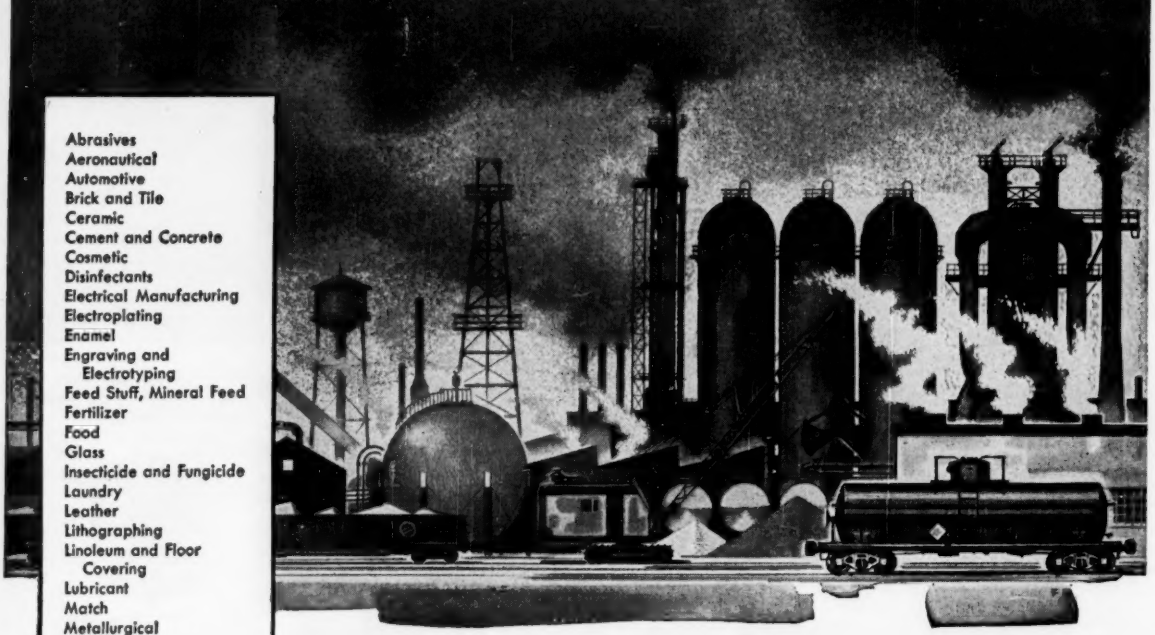
Choice of the correct Solenoid Valve for handling your corrosive fluid can be easily made by reference to the corrosion-resistant rating chart in the ASCO Catalog. This chart also indicates the type of valve construction required (iron, steel, stainless steel, etc.)

For complete information on ASCO's entire line of corrosion-resistant solenoid valves—and the time-saving rating chart shown in part above—write for the ASCO Corrosion-Resistant Valve Catalog.

ASCO®

Automatic Switch Co.
50-D Hanover Road, Florham Park, New Jersey
FRontier 7-4600

IS YOUR INDUSTRY LISTED HERE?



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Harshaw sells chemicals — thousands of them — for these and many other industries

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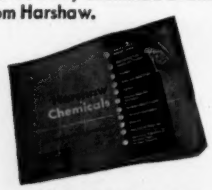
- Organic and Inorganic Dry Colors and Dispersions
- Driers and Metal Soaps
- Vinyl Stabilizers
- Ceramic Opacifiers and Colors
- Fluorides
- Glycerine
- Preformed Catalysts, Catalytic Chemicals
- Synthetic Optical Crystals
- Agricultural Chemicals
- Fungicides
- Chemical Commodities

FREE! This 16-page booklet lists the many chemicals available from Harshaw.



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THE HARSHAW CHEMICAL CO.

1945 EAST 97th STREET • CLEVELAND 6, OHIO

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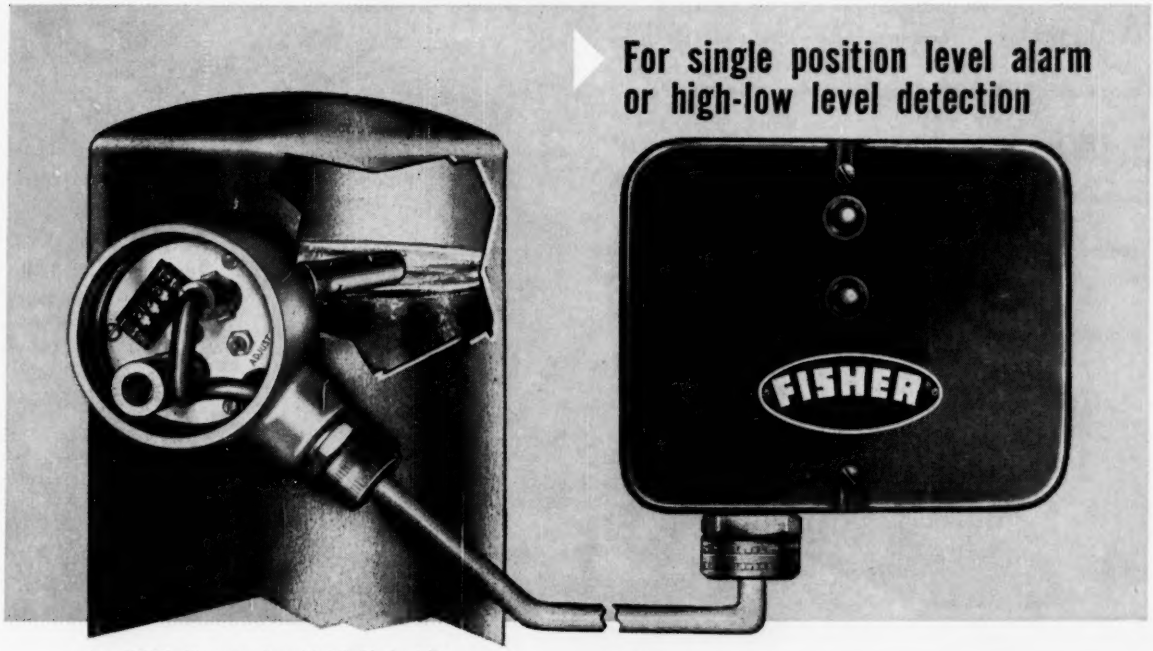
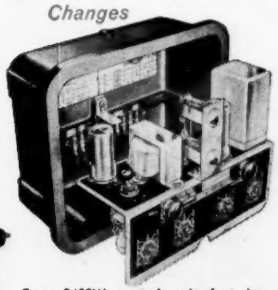
The Capaci-trol—a capacitance type level position detector



Type 2414W with sensing element installed horizontally for high level detection.

- *Compact Construction*
- *No Moving Parts*
- *Pressures up to 2500 psi*
- *Requires only 110 a. c. to operate*
- *Unaffected by Supply Voltage Variations*
- *Temperature Application Range From −50° F. to +150° F.*
- *Unaffected by Ambient Temperature Changes*

The Capaci-Trol is an electronic-electric level alarm and control unit for detection of level position in vessels—either as single point level detection for high or low level alarm applications or for high-low differential gap level detections. Units operate with power frequencies of 60 cycles utilizing a capacitance bridge circuit in conjunction with a rugged and durable Thyratron tube. Requiring only 110 a. c. supply voltage, the Capaci-Trol is completely self-contained and has no moving parts. The electrical output can be used to operate solenoid valves, motor starters, indicator lights, alarms, etc. All components of the Capaci-Trol are of the highest quality available, insuring maximum dependability and long life.



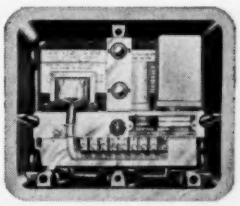
Type 2408W control unit featuring plug-in chassis.

AVAILABLE IN TWO MODELS

TYPE 2408W DIFFERENTIAL GAP CONTROLLER. The Type 2408W can be used in a wide range of conducting liquids for two-position control of level. Components are mounted on a plug-in chassis housed in a weather-proof aluminum case. Sensing elements available in lengths from 6" to 36" which is connected to remote control unit with coaxial cable. Maximum differential gap—80% of total length of sensing element. Minimum differential gap—0.5".

TYPE 2414W HIGH OR LOW LEVEL ALARM. The Type 2414W High or Low Level Alarm unit, as shown above, is designed for use in both conducting and non-conducting liquids. This, in general, includes the range from aqueous solutions to petroleum oils. Weather-proof housings are used for all components. Thyratron tube is in head portion of sensing element, thus requiring only standard wire in connecting to control case.

Write for Bulletin F-2408 for complete information



Type 2414W remote case contains power supply, relay and lights. Thyratron tube and level adjustment located in conduiet on top of sensing element.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER® Controls

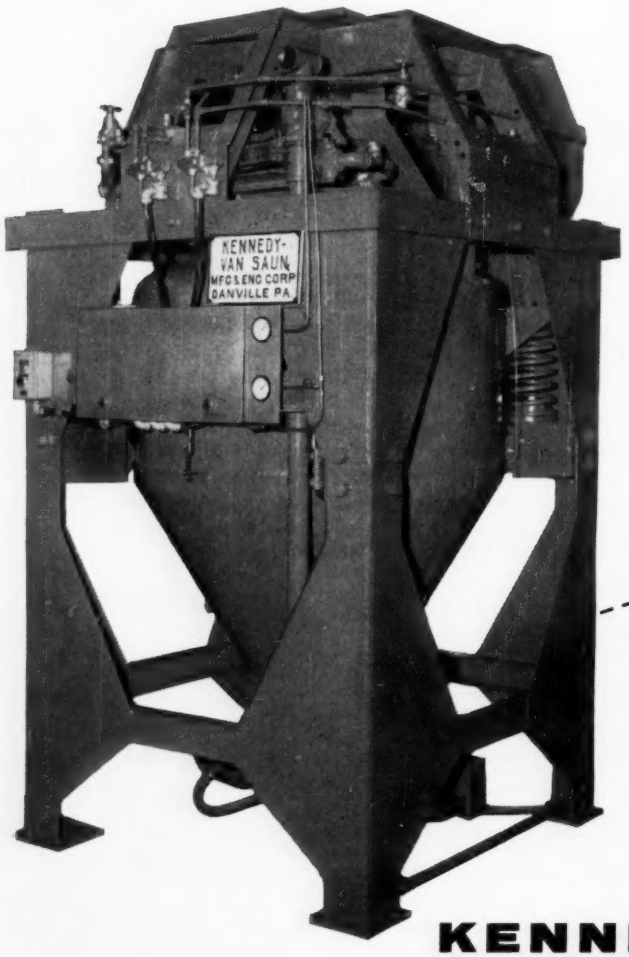
SINCE 1880

KENNEDY

PNEUMATIC CONVEYING SYSTEM

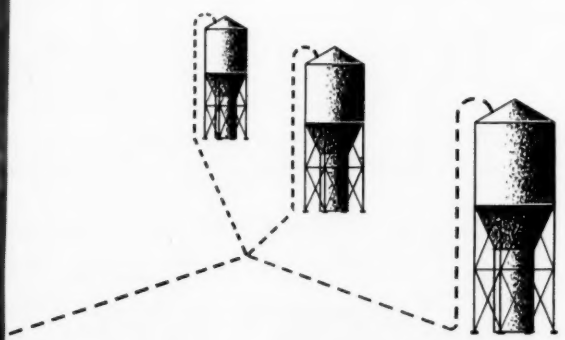
- **has NO MOTORS, screws or high speed moving parts**
- **uses higher pressures for greater efficiency and smaller pipelines**
- **uses air only when moving material at full capacity**
- **automatically measures quantities conveyed**
- **can handle several materials through one pump and pipeline without contamination**
- **complex distribution systems made fully automatic**

For over twenty-five years, KENNEDY has designed and built pneumatic conveying systems for America's largest industrial concerns. Let us show you how a KENNEDY System can be the most economical for *your plant.*



TYPICAL MATERIALS HANDLED

Carbon black	Lump lime
Hydrated lime	Cement
Petroleum coke	Barium sulphate
Aspirin crystal	Sodium bicarbonate
Soda ash	Anthracite coal
Dolomite	. . . and many others



Send for literature describing KENNEDY *Pneumatic Conveying Pumps, Air Activated Containers, Porous Tile Air Conveyors, Complete Pneumatic Conveying Installations, and Research and Testing Services.*

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U.S.I. CHEMICAL NEWS

★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★

U.S.I. Among Winners of Chemical Engineering Achievement Award

The 1957 Award for Chemical Engineering Achievement, presented at *Chemical Engineering's* Annual Award Dinner at the Waldorf-Astoria in New York on Tuesday, December 3, is a group award recognizing the pioneering application of chemical engineering principles and proceses in extractive metallurgy.

U.S.I. is one of 75 organizations in industry and government to share this honor, and is cited for its contribution to zirconium and titanium process technology. The U.S.I. processes for these metals are based on sodium reduction of the metallic tetrachlorides and are believed to be the most economical processes developed to date for the production of metal sponges.

The citations of the Committee of 90 senior educators, under the chairmanship of Dr. Walter Whitman of M.I.T., are limited to the newer metals: uranium, plutonium, zirconium and hafnium, tantalum and niobium, lithium, boron, beryllium, thorium and the rare earth metals. Also included as important to the nuclear industry are aluminum, nickel and titanium.

New Process to Synthesize DL-Piperitone Depends On Sodium Dispersions

DL-Piperitone can now be synthesized from ethyl acetoacetate, a by-product of neoprene manufacture. As against natural piperitone, a synthetic material has the advantage of dependable supply. Consequently an efficient and inexpensive method of commercial production has been sought for some time.

The technique of dispersing metallic sodium in inert hydrocarbon media, developed and perfected over the past several years by U.S.I., is at last providing a practical solution to the problem. A proposed commercial process based on this technique follows:

(1) Sodium and isooctane are agitated together to form a dispersion which is added to ethyl acetate in the mole ratio of 7.3 to 1. The resulting solution is heated.

MORE

Vinyl Heat Stability Improved When ISOSEBACIC® Acid Is Used As Plasticizer Intermediate

New Plant Starting Up To Produce ISOSEBACIC Acid

A newcomer among plasticizer intermediates, ISOSEBACIC acid, is improving the heat stability of polyvinyl chloride films. The table below is based on tests conducted by a formulator of top-grade films for seat-cover use. It gives the comparison between diisooctyl Isosebacate, an ester of ISOSEBACIC acid, and a commonly used plasticizer, diisodecyl adipate.

Comparing columns (1) and (2), it can be seen that heat stability improves 50%, from 30 to 45 minutes, when 15 parts of the Isosebacate replace an equal quantity of adipate. A comparison of columns (3) and (4) reveals that heat stability is improved 100%, from 30 to 60 minutes, when both ester concentrations are raised to 22 parts.

Tests also indicate that ester plasticizers formulated with ISOSEBACIC acid have improved color, odor, and oil and soapy water extraction properties. These properties are important for applications such as auto seat covers, furniture upholstery covers, shower curtains, luggage and handbags.

ISOSEBACIC acid is a mixture of isomers of sebacic acid in about these proportions:

2-ethyl suberic acid 72-80%
2,5-diethyl adipic acid 12-18%
sebacic acid 6-10%

In addition to the vinyl plasticizer application, the material is being evaluated in polyurethane foams, polyamides, polyesters, alkyd resins and jet lubricants.

ISOSEBACIC acid is a product of U.S.I. research. It is derived from butadiene and sodium, both available in unlimited supply. U.S.I. is now in the process of starting up its new ISOSEBACIC plant at Tuscola, Ill.

Diborane Now Produced Commercially; 3 Amine Boranes Being Researched

Diborane, precursor of pentaborane rocket fuel and promising as an intermediate, reducing agent, catalyst and flame speed accelerator, is being marketed in commercial quantities.

According to the manufacturer, physical and chemical properties are now completely determined. Chemical reactions which have been thoroughly investigated include those with ammonia, amines, phosphines, ethers, carbonyl compounds, hydrocarbons, metal alkyds and hydrides, and sodium.

Amine Boranes in Research Quantity

Also available, although in research quantities only, are dimethylamine-borane, trimethylamine-borane and pyridine-borane. Their utilization as selective reducing agents in non-aqueous solvents has been of most interest. They are polymerization catalysts and inhibitors for acrylates and vinyl compounds. In addition, applications as antioxidants and stabilizing agents have been suggested as promising possibilities.

Table of Field Test Data Comparing Diisooctyl Isosebacate Against DIDA as a Vinyl Plasticizer Intermediate

FORMULATION	Parts Per Hundred of Resin			
	1	2	3	4
PVC	100	100	100	100
DIOP (diisooctyl phthalate)	18	18	22	22
DIDA (diisodecyl adipate)	15	—	22	—
Diisooctyl isosebacate	—	15	—	22
Phosphate plasticizer	11	11	—	—
Stabilizer A	2	2	2	2
Stabilizer B	1	1	1	1
Stabilizer C	1	1	1	1
1. Volatility (active carbon method) 24 hrs. at 158 F, % loss	1.38	1.21	0.92	1.07
2. Clash-Berg, Tf, C	−24.4	−20.0	−23.9	−23.4
3. Heat Stability, minutes stable at 350 F	30	45	30	60
4. S.P.I. Impact Test (Masland) Pass/Fail F	−20/−25	−20/−25	−20/−30	−25/−30
Gauge	0.019"	0.020"	0.019"	0.021"
5. Germicidal Lamp Test, 16 hrs, tack	slight	slight	slight	slight
6. Blooming, Room Temperature, press polished	O.K.	O.K.	O.K.	O.K.

U.S.I. CHEMICAL NEWS

CONTINUED

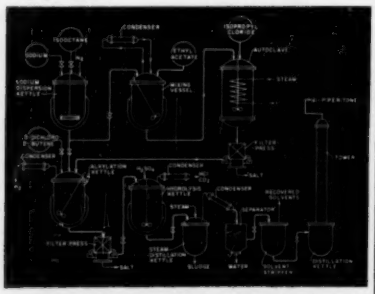
DL-Piperitone

(2) When reaction is complete, isopropyl chloride is added and the mixture is heated.

(3) The resultant slurry is filtered and the filtrate is alkylated with dispersed sodium to form the sodium enolate of ethyl oxisopropyl acetoacetate.

(4) 1,3-dichloro-2-butene in anhydrous benzene is added, and the mixture is refluxed until neutral.

(5) After filtration, the mixture is hydrolyzed with sulfuric acid, distilled and stripped of solvents. A crude, high-boiling dl-piperitone results. Further distillation yields pure dl-piperitone.



With this process, synthesis of DL-piperitone is reported to be commercially feasible.

New Standard Issued on Polyethylene Plastic Pipe

A new Commercial standard for black flexible polyethylene plastic pipe has been established by the Dep't. of Commerce, in cooperation with the Society of the Plastics Industry and the Nat'l. Sanitation Foundation.

The new standard, CS 197-57, specifies that "... the pipe shall be manufactured of virgin polyethylene, that no scrap material has been used, and that it is satisfactory for potable water." It also lists new dimensional tolerances and testing procedures.

Copies are available from Superintendent of Documents, U. S. Government Printing Office, Washington 5, D. C. for 10¢ a copy.

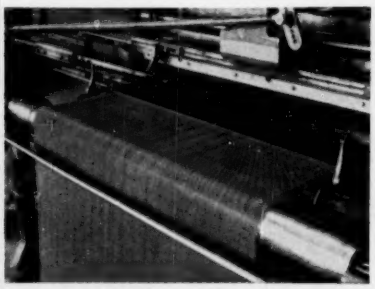
Corrosion-Resistant Mesh Is Now Produced with Improved Titanium Wire

The fabrication of titanium wire cloth now has reached a production basis. This is due primarily to improvements in quality of wire, which until recently lacked the needed uniformity and elongation, and had a tendency to work-harden rapidly and gall on metal-to-metal contact.

With wire-forming problems licked, and cloth being fabricated efficiently with high-purity and ductile grades of mill product, new applications are developing rapidly. Although noted for its high strength-to-weight ratio the biggest advantage of titanium in wire cloth form is its unique corrosion resistance. The metal has a corrosion rate of only .000001 inches per year in sea water, and is not subject to stress corrosion cracking in sea water or sea air.

Titanium wire cloth is being fabricated more and more into filter screens, catalyst screens or similar assemblies, where it handles mineral acid solutions, sodium hypochlorite, chlorides of all kinds, organic acids, alkalies and other reagents, with superior resistance to corrosion.

Several companies also report ability to make woven screen from zirconium wire, for those applications where zirconium corrosion resistance is superior to titanium.



Titanium wire cloth being woven (photo courtesy Cambridge Wire Cloth Company).

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

A silicone rubber which vulcanizes at room temperature has just been introduced for encapsulating, potting, sealing and caulking. Retention of rubber-like properties from —70 to 500°F is claimed. **No. 1301**

"The Rudiments of Feed Formulation", a 6 page reprint reviewing the industrial sources of animal feed constituents, the formulation of mixed feeds and the energy and nutrient values found therein, is now obtainable on request **No. 1302**

A new monomeric ester-type plasticizer for vinyls and cellulosics is described in a 4-page data sheet now available. Chemically it is di-2-ethylhexyl Isosebacate, reported about ⅓ lower in cost than the corresponding sebacate. **No. 1303**

Entirely new series of high molecular weight disazo red pigments for PVC and latex paints is said to combine the strength and brightness of organic pigments with the stability normally associated with inorganic pigments. **No. 1304**

Thioglycolic acid — its properties, reactions and uses — is described in a new 20-page catalog now available free of charge. An extensive bibliography of relevant patents and trade paper articles is included. **No. 1305**

Ethyleneurea (2-imidazolidinone), a new chemical, is now on the market. Used to make lacquers, varnishes, finishing agents, adhesives, plasticizers. Forms highly polymerizable vinyl and other derivatives. **No. 1306**

New series of zinc rich coatings to protect steel from the atmosphere and in marine and chemical use has been developed. Applied by brush or spray. Are said to be tougher, tighter, better bonded than old-type zinc coats. **No. 1307**

New adhesive for polyurethane foams is made with new, extremely fast-drying polymer, is said to lose its depression tack faster than any other material on market. Permits bonding with an adhesive as soft as the foam itself. **No. 1308**

A gas analyzer for measuring trace hydrogen, oxygen and nitrogen in metals has just been introduced for use right in the mill. Claimed to be only apparatus on market for both vacuum fusion and extraction. **No. 1309**

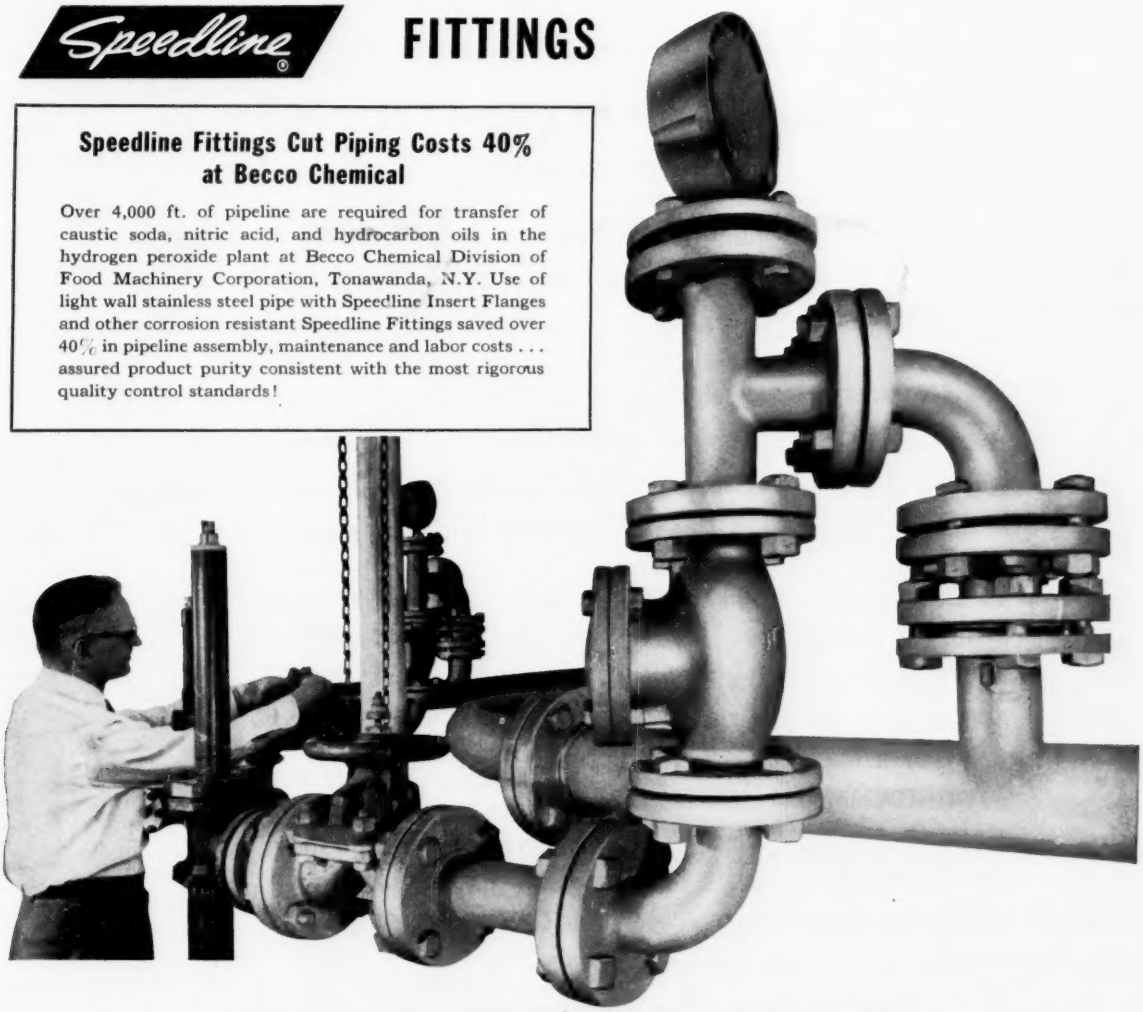
Pyridine N-oxide can now be obtained in commercial quantities. This exceptionally reactive derivative can be used to prepare many other pyridine chemicals valuable to the drug, dyestuff and allied industries. **No. 1310**

Where corrosion resistant piping is required

PROCESS PLANTS SPECIFY Speedline FITTINGS

Speedline Fittings Cut Piping Costs 40% at Becco Chemical

Over 4,000 ft. of pipeline are required for transfer of caustic soda, nitric acid, and hydrocarbon oils in the hydrogen peroxide plant at Becco Chemical Division of Food Machinery Corporation, Tonawanda, N.Y. Use of light wall stainless steel pipe with Speedline Insert Flanges and other corrosion resistant Speedline Fittings saved over 40% in pipeline assembly, maintenance and labor costs . . . assured product purity consistent with the most rigorous quality control standards!



Leak-Proof Joints without Welding—No residue traps form at points of juncture; process solutions are guaranteed *free* of "tramp iron" or other impurities. No threading, vanstoning or welding with a Speedline Insert Flange—a wrench and a Speedline expander assures a tight, leak-proof joint every time—without danger of contamination from welding operations.

"Tangential Feature" Simplifies Assembly and Modification—The extra straight section on *every* end of *every* Speedline formed fitting permits greater clearance for easier, faster joining—with *or* without welding—easier disassembly of pipelines when layout changes are required.

Discover how you can reduce costs wherever corrosion resistant piping is required at your plant . . . with Speedline Fittings, designed especially for use with low cost, light wall Schedules 5 and 10 stainless steel pipe.

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SPEEDLINE IS A REG.T.M. OF HORACE T. POTTS COMPANY

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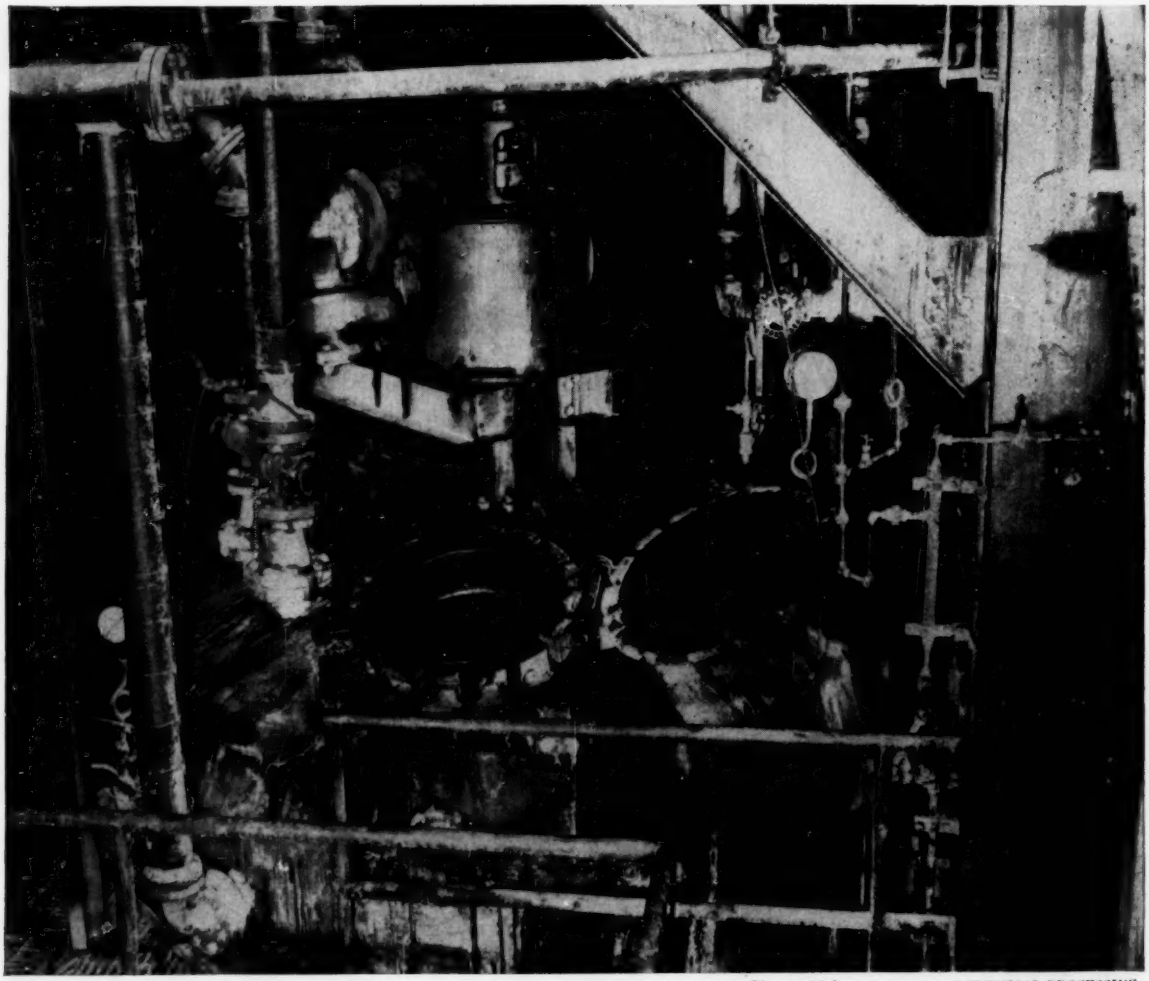


Photo and information courtesy of CHEMICAL PROCESSING.

Corrosion protection of Monel nickel-copper alloy extends over manway lip in this Monel-clad steel-jacketed autoclave. Solid Monel alloy is used for baffle plates and agitator parts. Three of these units were fabricated by the Colonial Iron Works Co., Cleveland, for Westvaco Chlor-Alkali Division of Food Machinery & Chemical Corporation.

Now good for three times the life! Monel withstands attack by abrasive silica in 50% caustic

This Monel-clad autoclave has been producing sodium silicate for six years at Westvaco's plant in South Charleston, W. Va.

Inspection indicates that the unit is good for at least another four years. That's better than three times the life of its predecessor.

In-plant corrosion tests determined choice

As the basis for redesign of earlier equipment, engineers at the Westvaco plant relied on the results of in-plant corrosion tests conducted cooperatively with Inco's Development and Research Division.

These tests indicated that Monel* nickel-copper alloy provided the maximum resistance to the abrasive-corrosive action of silica flour in an agitated 50% caustic at 175 psi and 350°F. The tests further indicated that a 0.125-inch Monel alloy cladding on steel could be expected to last ten years or more.

The first few months experience with the initial Monel-clad unit confirmed test results, so a second, and later a third, unit was installed. Maintenance and replacement savings have been substantial and all three units have plenty of service life left.

Metals that fail too soon call for corrective study and action

Inco is prepared to help you determine the nature and causes of metal failure and suggest materials able to withstand the conditions. All it takes to get this help is a note to our Development and Research Division.

*Registered trademark

The International Nickel Company, Inc.

67 Wall Street New York 5, N. Y.

INCO

INCO NICKEL ALLOYS

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically.

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

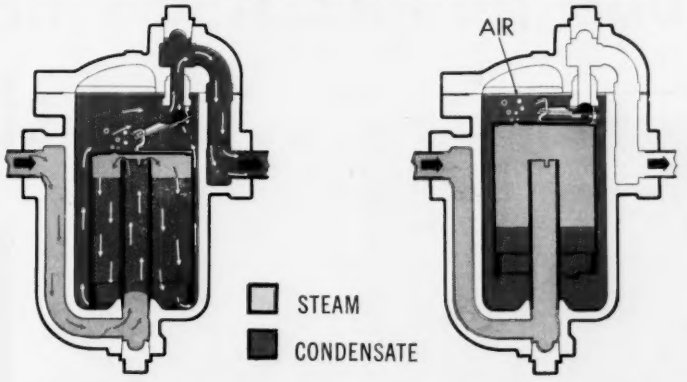
5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

Armstrong Machine Works
8581 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

HERE'S THE STEAM TRAP DESIGN THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic.....Organic.....Decorative.....Protective

Jobs for plastisols become bigger ...and still BIGGER!

Tank lining service that reduces costs

"Very good", reported the inspector at a large chemical company. He was examining the interior of one of their tank cars coated with phenolic Unichrome Lining B-124. Twenty-two trips in contact with highly corrosive 92% phenol left little mark on the protective coating.

APPLICATION SERVICE

Companies using tank cars or tanks can benefit from this experience. Throughout the country, skilled firms, such as Metalweld, Inc., of Philadelphia, are prepared to apply linings to open or closed tanks. Now no company has to forego the maintenance-saving, cost-cutting protection of enduring Unichrome Tank and Drum Linings.

NOTE: Unichrome *Plastisol* Coatings provide durable linings resistant to alkaline chemicals for which phenolic linings are unsuitable. Send for data.

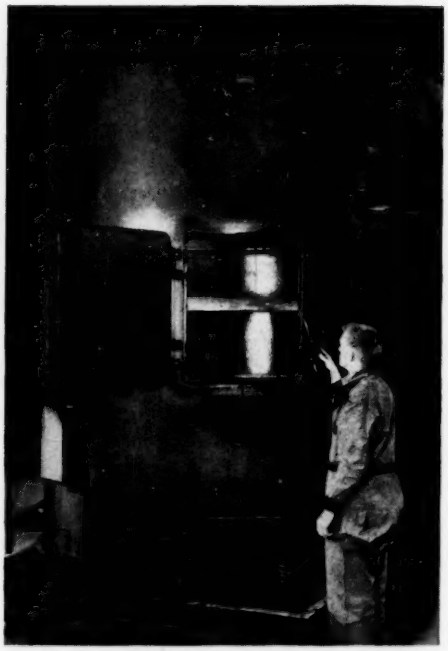
Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION
General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.

Unichrome Coatings give heavy duty corrosion-protection

Interior of this large fume scrubber was sprayed with Unichrome Plastisol by Kaybar, Inc. The thick vinyl coating withstands acids, alkalies, and many other corrosives. Being pore-free and seamless, the Unichrome Plastisol lining is now preferred for many jobs where rubber or plastic sheet linings were used formerly.

Note that sheer size is no longer a hindrance in applying plastisols. Firms like Kaybar with ever-expanding facilities are located at key points and can handle big jobs economically, quickly and professionally.



Spark testing is used to check the continuity and thickness of Unichrome Plastisol Coating applied on fume scrubber by Kaybar, Inc., Birmingham, Michigan.

EXTRAORDINARY PROTECTION

Unlike sheet materials, plastisols also conform to irregular surfaces without air pockets. The coatings stick tight — a Unichrome primer-plastisol system averaging a bond strength of 50 to 100 pounds per inch. They have good flexibility to absorb mechanical shock, resist abrasion to a remarkable degree.

Sprayable Unichrome "Super 5300" Plastisol provides films up to 60 mils per coat. When an object can be dipped, use of Unichrome "Series 4000" Plastisols will form coatings up to ¼ inch thick in one coat.

Even ordinary metals gain phenomenal ability to stand up in severe service when protected with such heavy duty coatings. Engineers are thus finding in plastisols the means to improve life of equipment, solve problems of corrosion and wear, cut costs.

Send for detailed bulletins — or name of nearest applicator of Unichrome Plastisols.

Struthers Wells

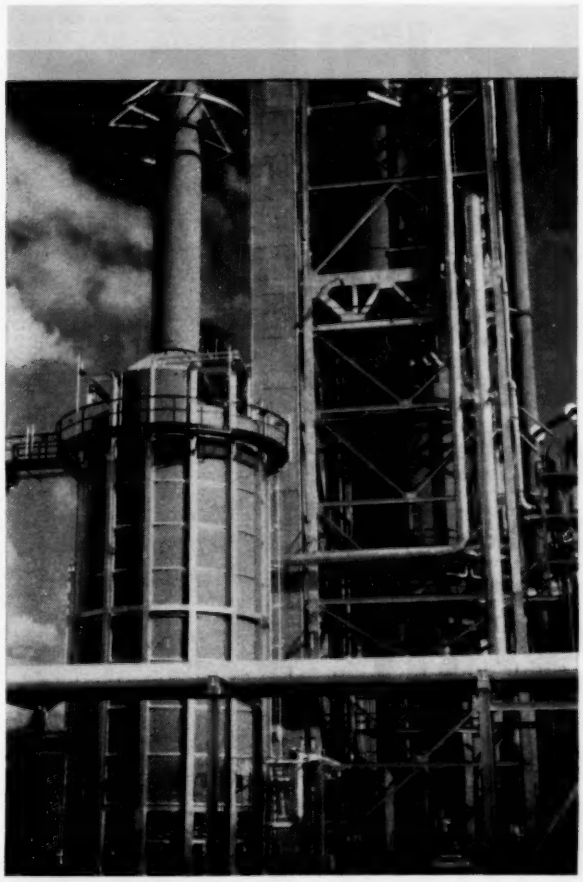
FIRED HEATERS

DIRECT OR INDIRECT HIGH TEMPERATURE HEATING for the PETROLEUM AND CHEMICAL INDUSTRIES

DIRECT HEATING
of hydrocarbon oils, gases, for gas cracking, steam superheating and many other services.

INDIRECT HEATING
using Dowtherm, Aroclor, heat transfer oil, liquid metals and other heat transfer mediums.

SPECIAL HIGH TEMPERATURE EQUIPMENT DESIGNED TO YOUR REQUIREMENTS



The photos show two tar separator heaters installed at a new refinery in Mississippi. These heaters are provided with alloy tubes, capacity 54,000,000 BTU per hour each. A total of seven Struthers Wells fired heaters were installed in this plant.

Struthers Wells supplies high-temperature heating equipment for a wide variety of services and industries. Temperatures range to above 1650°F. Struthers Wells heaters are characterized by trouble-free operation, long life and high thermal efficiencies. Hundreds of installations throughout the U.S. and some 15 foreign countries indicate the universal acceptance of Struthers Wells fired heaters.

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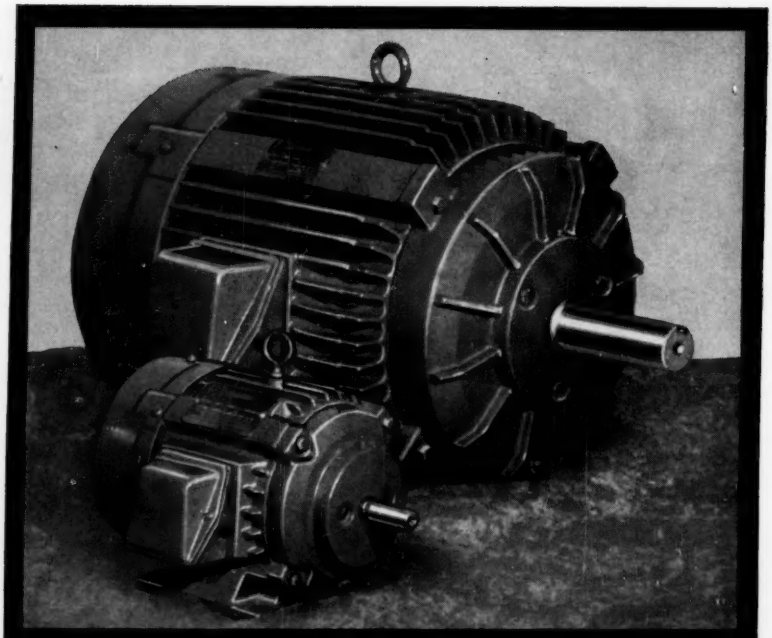
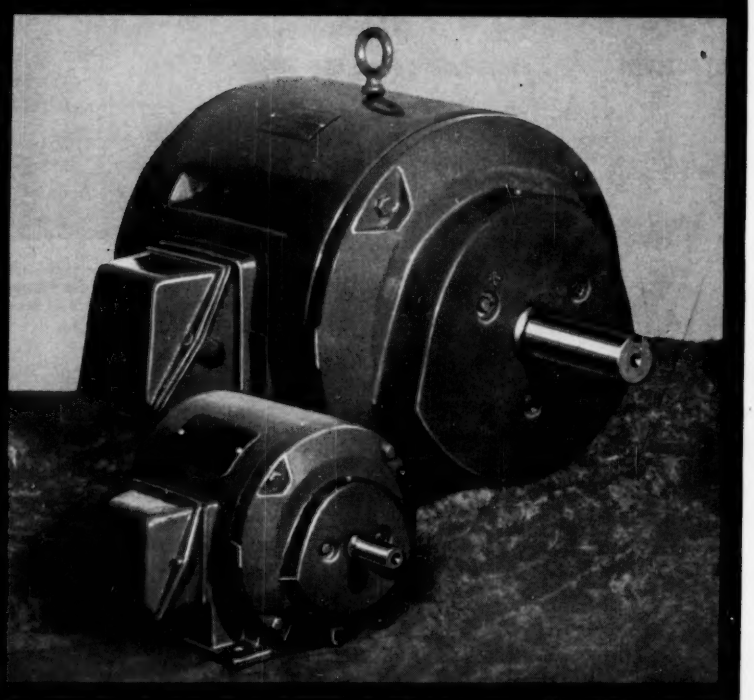
extends Totally Protected A-c. Motor line to 125 HP.





Reliance's proven Totally Protected design is now being extended thru 125 horsepower.

Now Totally Protected Motors will be available to you from 1 thru 125 hp. in new NEMA ratings.

Immediate delivery from stock today, 1 to 50 hp. Contact your Reliance representative for shipping schedules on other ratings. D-1573

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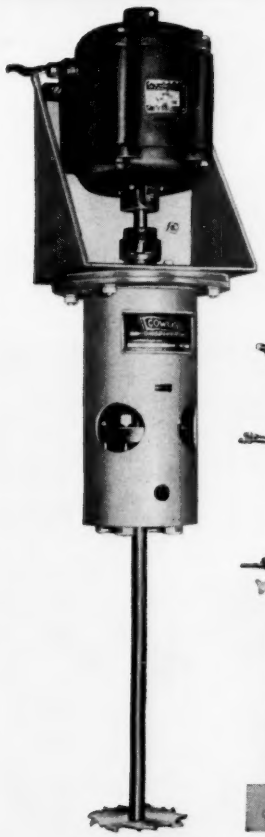
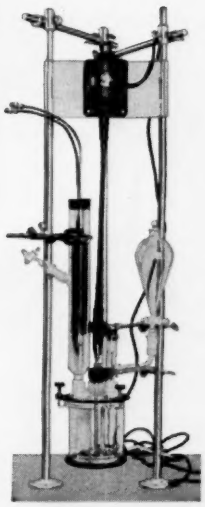


Cowles Pilot-Plant Sodium Dispersion Dissolver



Cowles Laboratory Sodium Dispersion Dissolver

Metallic dispersions finished in 30 minutes or less, particle size as small as two microns, with Cowles Dissolvers.

Largest Manufacturers have selected Cowles equipment

Highest quality metallic dispersions can now be easily controlled and produced in big volume, making many reactions commercially practical for the first time.

Key to the new method is the unique action of the patented Cowles impeller. With rim speeds of up to 6150 fpm, the impeller vanes create a zone of intense turbulence and hydraulic shear. The liquid is moved rapidly through itself until maximum dispersion is obtained. The Cowles thus gives several many very important advantages:

Versatility — prepares material for many reactions under conditions not heretofore possible.

Finer particle size — gives maximum reaction surface to dispersed elements.

More complete dispersion — assures complete homogeneity of material.

Greater speed — cuts finished dispersion time substantially.

Cleanliness — self-cleaning impeller will not clog with metal.

Safety — gives the close control necessary with highly active materials.

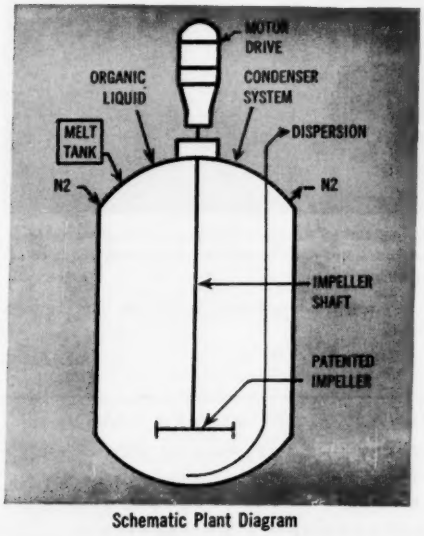
Predictable results — laboratory and pilot-plant models provide results easily duplicated in larger models.

New Cowles Dissolvers with properly sealed and specially designed drives for metallic dispersions are available for all purposes. Included are "package" models in both laboratory and pilot plant types, and models for commercial production. All are thoroughly proven in actual plant operations and represent the broad experience and know-how of our organization – the established leader in its field. Specialized engineering assistance can be supplied if desired.

For complete information write today for Technical Bulletin No. 21-1957, "Metallic Dispersions with the Cowles Dissolver."

Additional Cowles Dissolver models are available for efficient processing of all solid-liquid, liquid-liquid and gas-liquid products.

Take advantage of the unusual *Morehouse-Cowles Processing Equipment Application Service* at no obligation – for a comprehensive survey of your plant requirements and end products, with laboratory assistance and in-plant tests at our risk.



Schematic Plant Diagram

5702-H

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YOU CAN SAVE... time, labor and money BY CONVERTING your hand-operated valves...

TO LimiTorque®

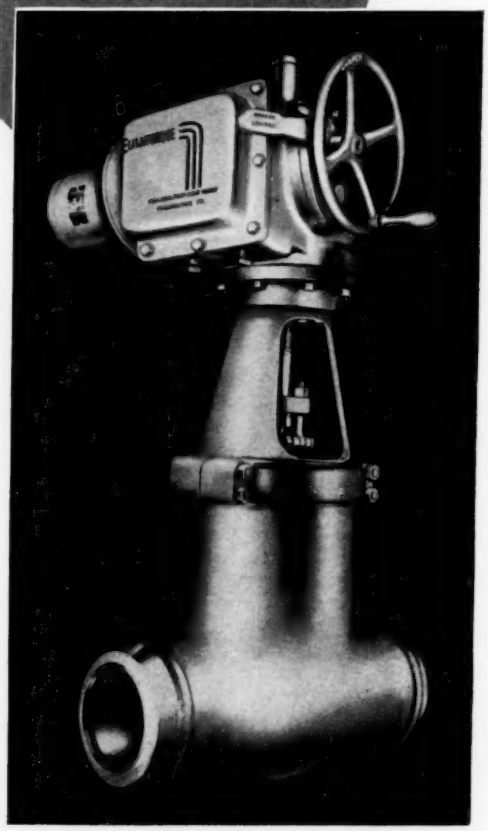
Trouble-Free Motorized Valve Operation

Why not be modern and thrifty too,—follow the example of hundreds of plants of all types. *Convert* your present hand-operated valves to LimiTorque "push-button control"—*save time, labor and money.*

In most instances, LimiTorque conversion requires only minor changes to the valve. Your LimiTorque Valve Operators can be furnished as a completely packaged unit including electrical controls and push button. Simply wire the power leads to your source of electricity.

With LimiTorque, one finger does the work of many hands, by permitting key personnel to operate, and know the exact position of each valve from a centrally located control panel.

In addition, LimiTorque protects seats, discs and stems from damage, by automatically shutting-off power source should an obstruction interfere with valve closing. LimiTorque-operated valves are always seated tightly because the valve disc seating thrust is accurately maintained in each closing-cycle, through a micrometer-adjusted torque limiting mechanism.



LimiTorque can be field-mounted on your existing valves—contact your valve manufacturer or nearest LimiTorque sales-engineering office.

Send for complete new Catalog L-550, on your business letterhead.

LimiTorque®

PHILADELPHIA GEAR WORKS, INC.

ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

BRIEFS for buyers of

Caustic Potash
Sodium Sulfides
Inert Lubricants
Sodium Chlorate

Facts on caustic potash

While there are a few growing uses for dry forms of caustic potash (notably the powder and flake), about 8.5 out of every 10 pounds of KOH purchased in the U.S. are bought as liquid, either standard or low chloride grade.

Reasons for this are pretty clear: liquid KOH is easier to handle than solid forms, and cheaper to buy (particularly in the higher concentrations).

Shipping strength of liquid KOH is limited, by its penchant for crystallizing in cool weather, to a narrow range between 45% and 52%. Big-volume users sometimes order 52% to keep freight cost down; this is about the practical limit on strength.

NIALK® liquid caustic potash is regularly shipped at 45% to 52% concentration. It is extremely low in iron content.

If your process economics favor a solid form of KOH, you can get a wide choice by specifying NIALK brand. We ship 90% caustic potash as fused solid, flake, granular, walnut, broken, powder, or crushed. ("Walnut" is used in liquefying air; flake and powder often go into cleaning compounds, mixed with caustic soda, soda ash, metasilicates, and phosphates.) We also supply 85% KOH in flake or solid form.

KOH is a "specialty" alkali. You buy it for specific properties you just can't get from other alkalies. Making it takes special skills, too.

You can have confidence in the same skill that pioneered caustic potash on this continent and has supplied NIALK KOH for half a century. We continue to supply a major portion of the total requirements of this country.

Can you pass this sulfide quiz?

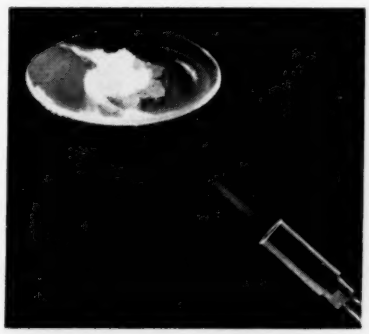
Here's a quick way to tell if you're getting good value in the sodium sulfide and sodium sulfhydrate you buy:

1. Do you always receive sulfide or sulfhydrate in brand-new drums?
2. Is every drum lacquer-lined to prevent iron contamination?
3. Is iron content consistently lower than 10 ppm?
4. Are drum lids sealed so they can't pop open in handling or storage?
5. Can drums be resealed easily?

If you have to say "no" to any of these questions, you're probably risking some contamination in your process. To some, this is a serious matter.

Even if it *isn't* serious, why put up with it at all—when you can get sodium sulfide or sulfhydrate that's virtually iron-free, protected by all the safeguards mentioned above?

To do so, simply write *Hooker* on your next purchase order for either of these products. Why not order a trial quantity now?



You can't burn this grease

You may at first be discouraged at the things you *can't* do to this product. But therein lies its value.

Besides being completely nonflammable, it won't break down in the presence of oxygen, hydrogen peroxide, concentrated mineral acids and alkalies. It's unaffected by heat up to 300° C; is stable at very low temperatures, too; is odorless and nontoxic.

What's its name? FLUOROLUBE®. It's a high-density addition polymer of trifluorovinyl chloride. The basic polymer can be fractionated into many grades, ranging from low-viscosity colorless oils through heavy oils to opaque greases. All have excellent lubricating qualities.

Fluorine and chlorine, accounting for nearly 80% of the molecule, contribute to the high densities and complete fire safety of FLUOROLUBES.

What *can* you do with them? Some suggestions: lubricate ultraprecision instruments; seal pumps, valves, pipe joints in equipment handling oxygen, hydrogen peroxide, nitric acid, and other corrosives; lubricate PVC fittings, plug cocks, vacuum pumps in highly corrosive service.

You'll find other ideas on use, plus specifications and typical properties, in a data file on FLUOROLUBES which you can get by checking the coupon.

More $NaClO_3$ coming

Thanks to our OLDBURY® Products plants at Niagara Falls, N. Y., and Columbus, Miss., we're presently the nation's largest producer of sodium chlorate. But even that isn't good enough to meet *tomorrow's* needs.

The Columbus plant has been in production since 1954. In 1956 we upped its capacity by 5,000 tons per year. Now we're building again. By early 1958, another 5,000 tons yearly will be on tap.

Assuming you're in the market for sodium chlorate, may we submit these three reasons for making Hooker your supplier:

1. Fastest service you can get east of the Rockies.
2. Skilled technical help when you need it.
3. Sodium chlorate of 99.5% minimum purity.

May we spell out these advantages for you in more detail? If so, just write to *Hooker Electrochemical Company at the address given below.*

For more information on chemicals mentioned on this page, check here:

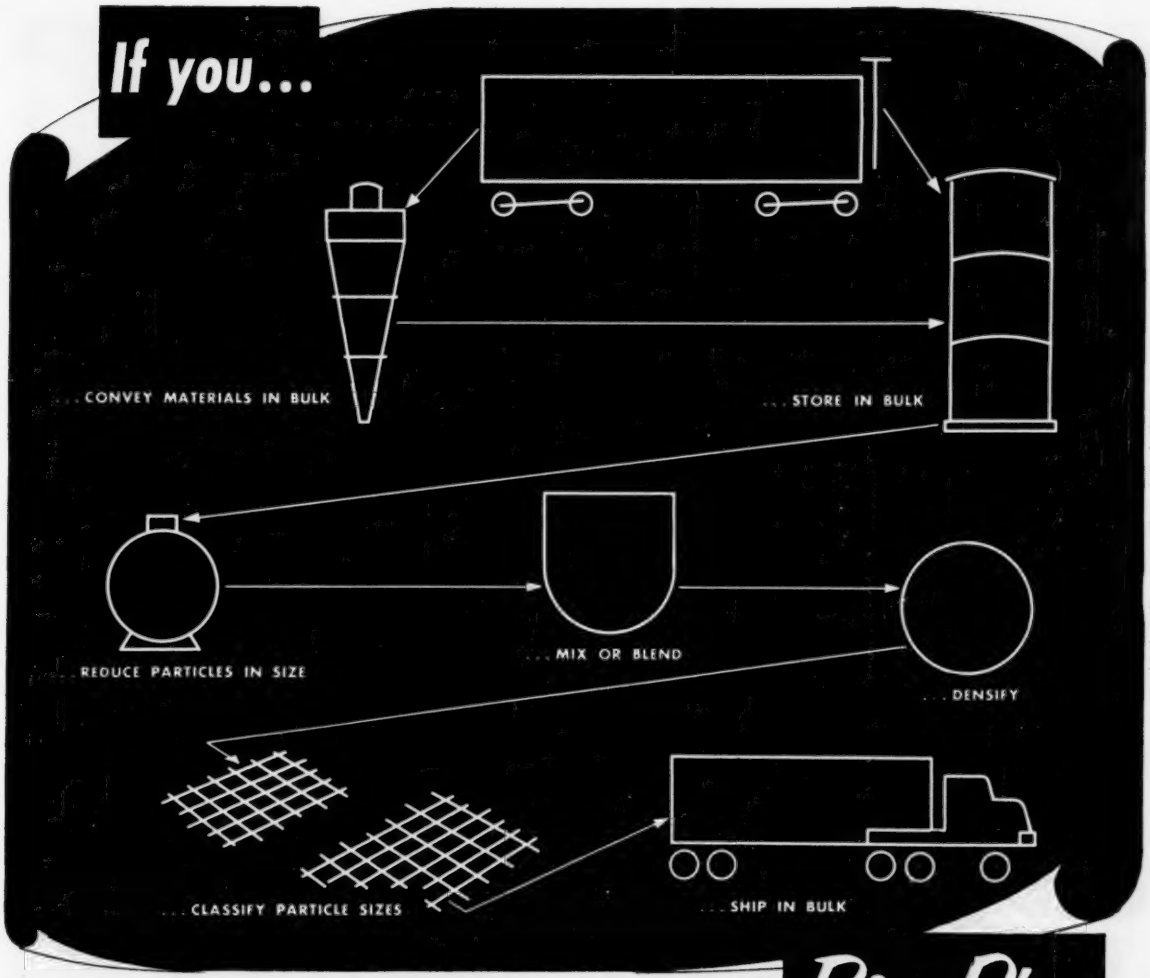
☐ Caustic Potash ☐ FLUOROLUBES
☐ Sodium Sulfide ☐ Sodium Chlorate
☐ Sodium Sulfhydrate ☐ New list of products—Bulletin 100-A

Clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

HOOKER ELECTROCHEMICAL COMPANY
401 FORTY-SEVENTH STREET, NIAGARA FALLS, N. Y.

Niagara Falls Tacoma Montague, Mich. New York Chicago
Los Angeles Philadelphia Worcester, Mass.
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS



SPROUT-WALDRON offers you a *Big Plus*

Many of America's greatest processing companies (names on request) can testify that...

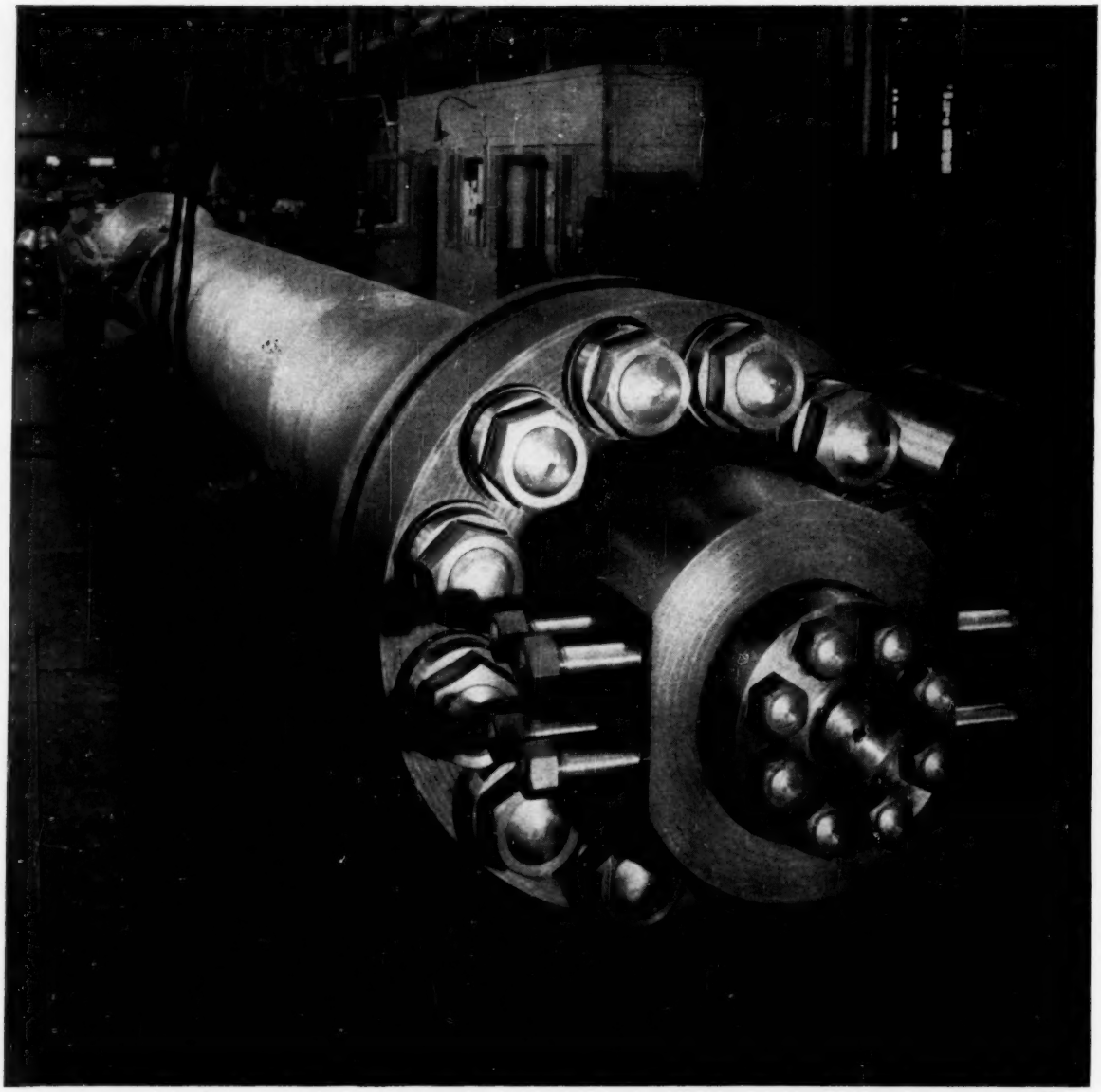
Sprout-Waldron installations achieve a degree of specific fitness that is unusual in industry.

This success is due to a unique application of engineering know-how and imagination to the solving of difficult processing problems . . . PLUS . . . wide selections of virtually all types of processing equipment ...PLUS...an ability to "adaptioneer" machines to meet individual needs...PLUS... manufacturing facilities that include fabricating, machining, custom founding, woodworking, and laboratory testing.

Put these **BIG PLUS** factors to work for you. Let Sprout-Waldron analyze your processing problems and recommend solutions. You'll find new ways to cut costs and save money.

Write for free Bulletin 95—an informative treatise on equipment and systems for processing dry and semi-dry materials.

SPROUT-WALDRON
Manufacturing Engineers Since 1866
15 LOGAN STREET • MUNCY, PA.



Big Ammonia Converter Ready for Duty

Here's a strapping big pressure vessel undergoing its final checkup just before shipment. A forged ammonia converter, the vessel is a real heavyweight, the kind Bethlehem is often called upon to build.

It weighs more than 82 tons and is about 55 ft long. It has an ID of 29 in. and a body OD of 42 in. Under hydrostatic test it was subjected to pressures reaching 14,000 psi.

Bethlehem is equipped to build vessels both larger and smaller than this one. Moreover, they can be furnished in a wide range of types to meet the needs of the chemical, rubber, petroleum, and food-processing industries.

So, we suggest you get in touch with us whenever your program includes new vessels. Our engineers will gladly help in the planning of forged autoclaves, reactors, converters, separators, filters, or high-pressure accumulators.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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And you'll find that the complete engineering facilities of Commercial Filters Corporation are at your service. Send today for your free catalog.

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MELROSE 76, MASSACHUSETTS
PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

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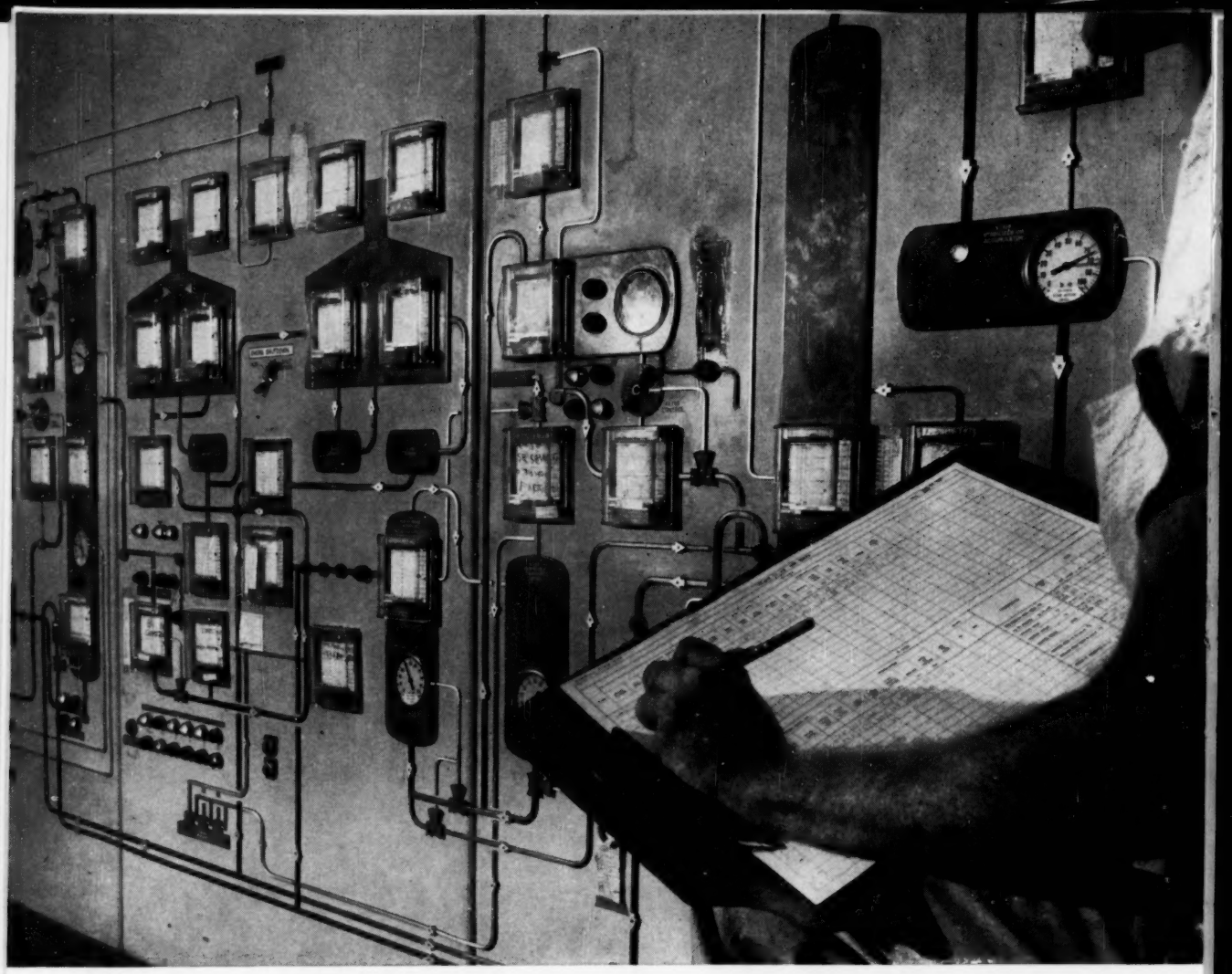
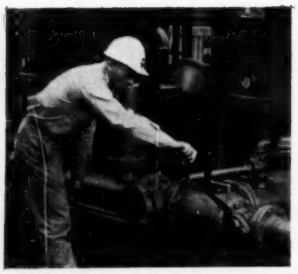


Typical Air-Operated Instrument Panel

To keep down-time down . . .

Come to Kemp



Semi-automatic Kemp Convection Dryer protects vital instruments at Grace Chemical's Woodstock, Tennessee plant. Unit operates around the clock preventing corrosion and line freezes with a bare minimum of attention.

A Kemp gas dryer in your operation can put an end to many costly shut-downs by protecting air-operated instruments from corrosion and freezing or jamming . . . efficiently drying inert gases for purging and blanketing . . . or drying atmospheres and process gases in hundreds of other applications. Operations are faster and safer, with better quality control and frequently reduced costs.

And Kemp dryers, operating on the dynamic drying principle, are noted for dependable operation. Rugged Kemp dryers will do your drying job around the clock, month after month, without stoppages or major maintenance. Kemp design reduces utility and operating costs, uses desiccants more efficiently, and eliminates process gas contamination. Units dry to lower dewpoints to give your processes and instruments highest possible protection.

Call your Kemp Representative, listed in the Chemical Engineering Catalog, for detailed information and a no-obligation survey of your dryer needs. Or write direct, for Bulletin D-100. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Inert Gas Generators

KEMP OF BALTIMORE

Kemp Industrial Carburetors

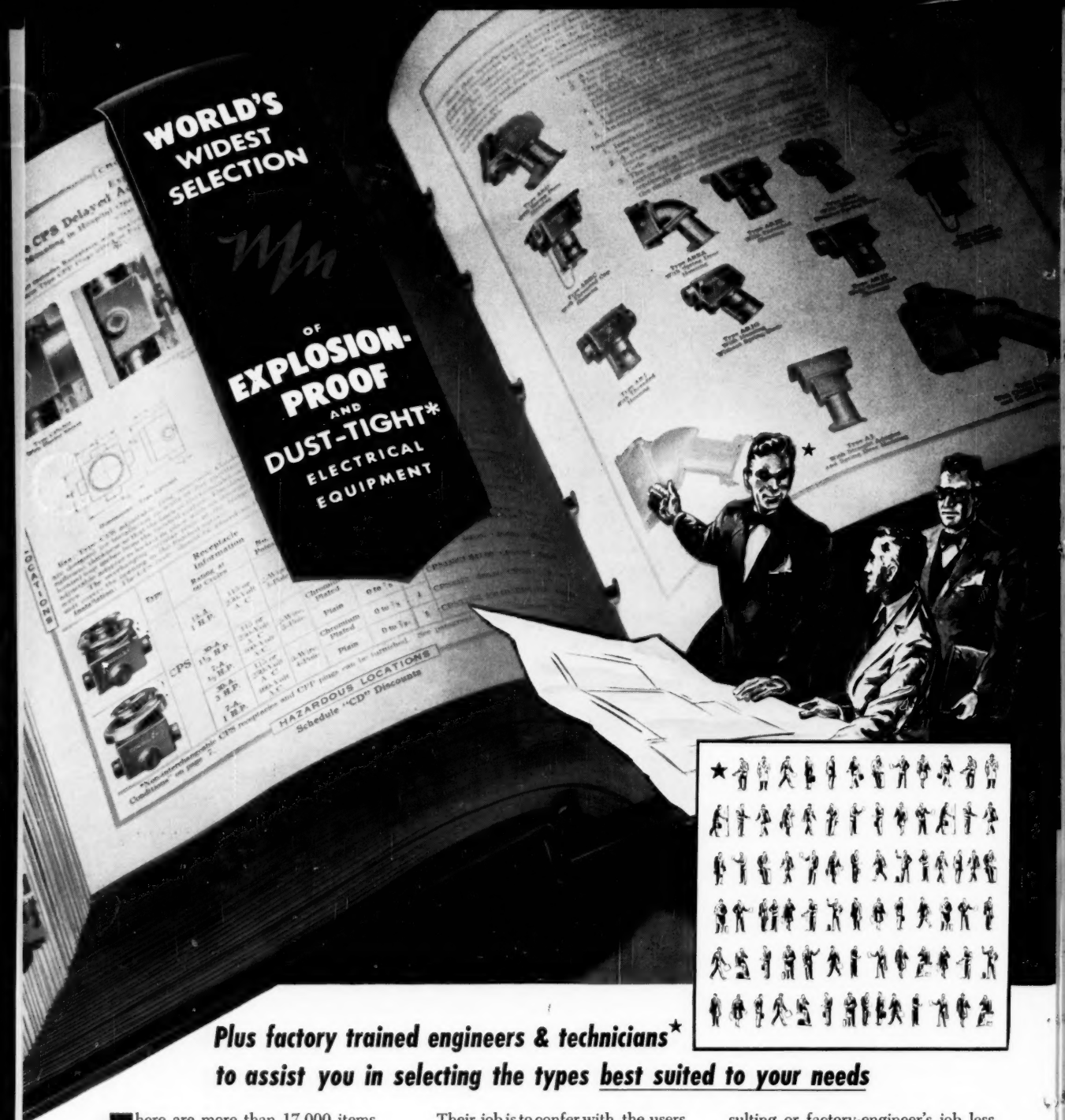
Kemp Oriad Dryers

Chemical Engineering

Developments

JAN. 27, 1958

Department Index



Plus factory trained engineers & technicians★ to assist you in selecting the types best suited to your needs

There are more than 17,000 items in the Crouse-Hinds line of Condulet® and floodlighting equipment. Each is designed with some specific advantage or quality that makes it best suited for a particular application.

Of course, no engineer, electrician or contractor with a regular job to do, could possibly keep in mind all the pertinent data and information concerning each of these items. That's why Crouse-Hinds maintains a factory-trained field staff of 80 graduate E.E.'s and technical men.

Their job is to confer with the users of Crouse-Hinds equipment and to point out the reasons why certain Condulet equipment or floodlights are better suited for a particular job than others. With a broad grounding in the details of the National Electrical Code and a trained alertness for spotting explosion hazards in unsuspected places, they make a consulting or factory-engineer's job less onerous.

Their service is prompt and without obligation. Naturally they usually work on jobs of sufficient size to merit top-level attention, but even a small job with a large problem gets the same careful appraisal. If you'd like to talk or correspond with such a specialist, just write, wire or phone.

CROUSE-HINDS COMPANY

*Dust-ignition-proof

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Crouse-Hinds Company of Canada, Ltd.: Toronto, Ont.

Offices: Baton Rouge · Birmingham · Boston · Buffalo · Chicago · Cincinnati · Cleveland · Corpus Christi · Dallas · Denver · Detroit · Houston · Indianapolis · Kansas City · Los Angeles · Milwaukee · New Orleans · New York · Philadelphia · Pittsburgh · Portland, Ore. · Salt Lake City · St. Louis · St. Paul · San Francisco · Seattle · Tulsa · Washington · RESIDENT REPRESENTATIVES: Albany · Atlanta · Baltimore · Charlotte · Chattanooga · Jacksonville · Reading, Pa. · Richmond, Va. · Shreveport

DEVELOPMENTS . . .

JANUARY 27, 1958

Chementator

C. H. CHILTON

√ **Colored tires to match your car may hit the road soon. Columbia-Southern reports 45,000-mile tread life in test tires reinforced with silica rather than carbon black.**

√ **New type of liquid-metal-fuel nuclear reactor will be designed by American Nuclear Power Associates, based on Raytheon Mfg. Co.'s concepts. Fuel is uranium in bismuth, cooled by helium at 500 psi. and exit temperature of 1,300 F. Helium will generate steam at 850 psi. and 900 F.**

√ **From fume to perfume—that's the story of Edmonton (Alta.) Transit System's diesel buses. Fuel now contains 0.02% of Rhodia's Alamask D1-2K to sweeten exhaust odors.**

Chloride route aims to get more copper

In a bid to tap the many deposits of low-grade copper oxide ores scattered through the Southwest, U. S. Bureau of Mines is dusting off the old "segregation" process.

Bureau reports bench-scale recoveries of 73-96% of copper content on ores assaying 0.78-5% Cu, estimates that a commercial plant could process 1,000 tons/day ore for $3.30/ton. Results are encouraging enough so that USBM wants to build a 50-ton/day pilot unit to gather more accurate cost data.

In latest version of process, crushed ore (−10 mesh) is heated at 1,300 F. with sodium chloride and coke or coal. Salt decomposes, reacts with copper compounds forming cuprous chloride. Vaporized $CuCl_2$ is reduced to small copper flakes by the carbon.

Copper flakes remaining in the original ore are liberated by further fine grinding. Then a conventional xanthate flotation recovers the copper.

LTC catalyzes oil-coal collaboration

Mutual aid may soon displace traditional petroleum-coal rivalry. It will come about via the good offices of low-temperature carbonization of coal.

Big obstacle to widespread commerical use of LTC processing has been economic disposal of the 10-40 gal. of tar which comes off when you carbonize a ton of coal or lignite. The answer: Sell it to petroleum refiners as a crude feedstock for making liquid fuels.

The East Germans are already doing this. A lignite carbonizing plant at Rositz is building a cracking unit which will process 90,000 tons/yr. of lignite tar, along with 80,000 tons of press oils, to yield 100,000 tons of gasoline and diesel fuel, as well as tar products, gas and coke. Gasoline and diesel fuel will be piped 19 miles to a refinery at Boehlen for further processing.

Parallel developments in the U.S.:

(Continued on page 56)

Life on the Chemical Newsfront

THE "CHEMICAL STORY" IS READ BY SHOPPERS on tags describing the extra qualities imparted to textiles by chemical treatments. Stain and wrinkle resistance, shrinkage control and water repellency are among the many benefits of the various CYANA® finishes offered to textile processors by Cyanamid. CYANA tags on garments and yard goods educate consumers to appreciate—and demand—the benefits offered by chemistry in improving comfort or extending wear.
(Organic Chemicals Division)

MEATS AND OTHER PERISHABLES "BREATHE" EASIER when wrapped in plastic which is permeable to air, though moisture resistant. Such films can be made with N-*tert*-butylacrylamide-acrylonitrile copolymers. With styrene, N-*tert*-butylacrylamide copolymerizes to give tougher resins with excellent craze resistance. Used in melamine-formaldehydes, N-*tert*-butylacrylamide-acrylonitrile copolymer contributes craze and crack resistance as well as dimensional stability. Many copolymerization possibilities are discussed in the N-*tert*-butylacrylamide bulletin. (Market Development Department)

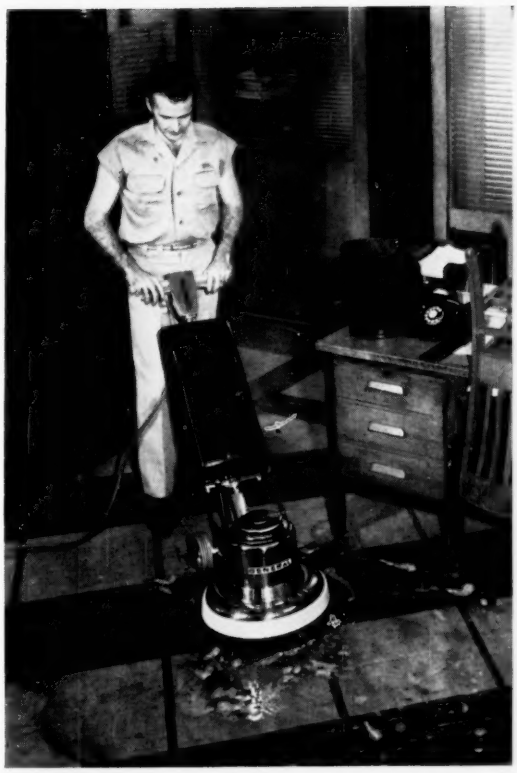
NEW CYADYN* DYNAMITE will be exhibited for the first time to the rapidly expanding and progressive quarry industry at the 41st annual convention of the NATIONAL CRUSHED STONE ASSOCIATION. Formerly known as CX-307, CYADYN has proved to be an economical cap-sensitive explosive possessing very good water resistance. CYADYN is also finding use as a primer for blasting agents, since only an electric blasting cap is needed to detonate this new dynamite.

(Organic Chemicals Division)

BRIGHTER FLOOR COVERINGS are the result when CYQUEST 40* *sequestering agent* is used to remove insoluble soap curds. These dirt-collecting films, which tend to build up on linoleum, tile and other floor surfaces, are solubilized and prevented from reforming by the chelation of the soap-precipitating metal ions. CYQUEST 40 is available as a clear solution which can be directly incorporated into your liquid detergent or soap products.

*Trademark

(Industrial Chemicals Division)



NEW BOILABLE THERMOPLASTIC HOUSEWARES withstand the scalding temperatures of automatic dishwashers and sterilizing immersion in boiling water without softening or changing shape. They are made of CYMAC® *methylstyrene*, a new heat-resistant thermoplastic developed by Cyanamid. Rigid thermoplastic products made of CYMAC molding compounds also withstand sub-zero temperatures and can be made in a full range of translucent and opaque colors. (Plastics and Resins Division)

CYANAMID

AMERICAN CYANAMID COMPANY

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

For further information on these and other chemicals, call, write or wire American Cyanamid Company

• Coal companies, power companies and oil refiners in the mountain states are reported to be well advanced in plans for carbonizing Wyoming coal. Power plants would burn the char, refiners would eagerly sop up the tar for conversion to liquid fuels.

• Southern Research Institute reports that its LTC research project contemplates disposal of tar by hydrocracking to yield gasoline and simple aromatics. Cost estimates indicate that tar at 8.6¢/gal. ($3.60/bbl.) will give a reasonable return on investment.

• Lummus Co. has successfully run LTC tars through a pilot delayed coking unit to make gasoline and coke. Plans for a commerical venture are said to be in the making.

Until now most groups hoping to commercialize low-temperature carbonization have assumed that the tar should be treated gently to conserve its rich chemical values. "Downgrading" it by cracking means that it must be priced about equal to crude petroleum.

This is already feasible in East Germany because the tar there is less costly than petroleum. Such a time may not be far off here.

HCl recovery features uranium process

Liquid ion exchange—alias solvent extraction—gains a new practitioner this month as Vitro Uranium Co.'s 660-ton/day uranium recovery unit at Salt Lake City reaches full-scale production.

Vitro's choice of stripping agent underscores the basic physical and chemical nature of this process. Unlike Kerr-McGee, which uses 10% soda ash to displace uranium from phosphoric ester "solvent" (*Chem. Eng.*, Apr. 1957, pp. 148-150), Vitro uses 31.6% hydrochloric acid. Thus in ion exchange terms, one uses a sodium cycle, the other, a hydrogen cycle.

The two firms also differ in choice of solvent. Kerr-McGee decided on a dialkyl, di-2-ethyl hexyl phosphoric acid, primarily on the basis of its commercial availability. Vitro, on the other hand, picked a monoalkyl, dodecyl phosphoric acid, on the basis of its greater efficiency, despite the fact that it was not then available (it is made from dodecyl alcohol and phosphoric anhydride).

Most compelling reason for Vitro's using HCl instead of soda ash as stripping agent is that monoalkyl solvents are soluble in soda ash solution. Vitro stresses another advantage of HCl—easy recovery for reuse. This is done via a two-stage, vertical, falling-film evaporator. The firm says it expects to get "almost complete" HCl recovery.

Offsetting this advantage to some extent, however, is the cost of evaporation equipment and the extra problems of handling HCl. Vitro also has to add a calcining step to its flowsheet to control chloride concentration of precipitated uranium yellow cake.

How to limit estimating uncertainties

Should preliminary cost estimates for proposed new processes and products be based on optimistic or conservative assumptions?

This dilemma may yield to a pincers movement being tried by Du Pont cost engineers. They simply make two estimates—one optimistic, the other conservative—as to cost of finished product and plant facilities.

As described by W. S. Gilfoil and E. L. Mongan at the Chicago AIChE meeting last month, the optimistic estimate assumes that all research and engineering problems will be solved at low cost. The conservative estimate, on the other hand, includes enough safety factors to guarantee that the plant can turn out the required quantity and quality of product.

In the early development stages the two sets of cost figures will usually be far apart. However, as research and engineering studies turn up better information, successive revisions of the estimates will show a converging trend. The difference finally disappears at the point where enough reliable data are available for the final construction cost estimate.

Big boom in ammonium nitrate use

Fertillizer-grade ammonium nitrate is literally blasting open a big new chunk of the billion-lb./yr. industrial explosives market.

While ammonium nitrate has been around a long time as a component of mixed explosives, only in the past two years has it come into wide use as an open-air (surface) blasting agent in its own right.

As brought out so vividly by the Texas City disaster, ammonium nitrate fertilizer packs a powerful punch when mixed with a combustible material and set off with a detonator. In the technique originated by Maumee Collieries (Terre Haute, Ind.), coal dust is mixed in as the "activating" agent. Today's

(Continued on page 58)

There's an important difference in

B&A® Purified AMMONIUM SULFATE

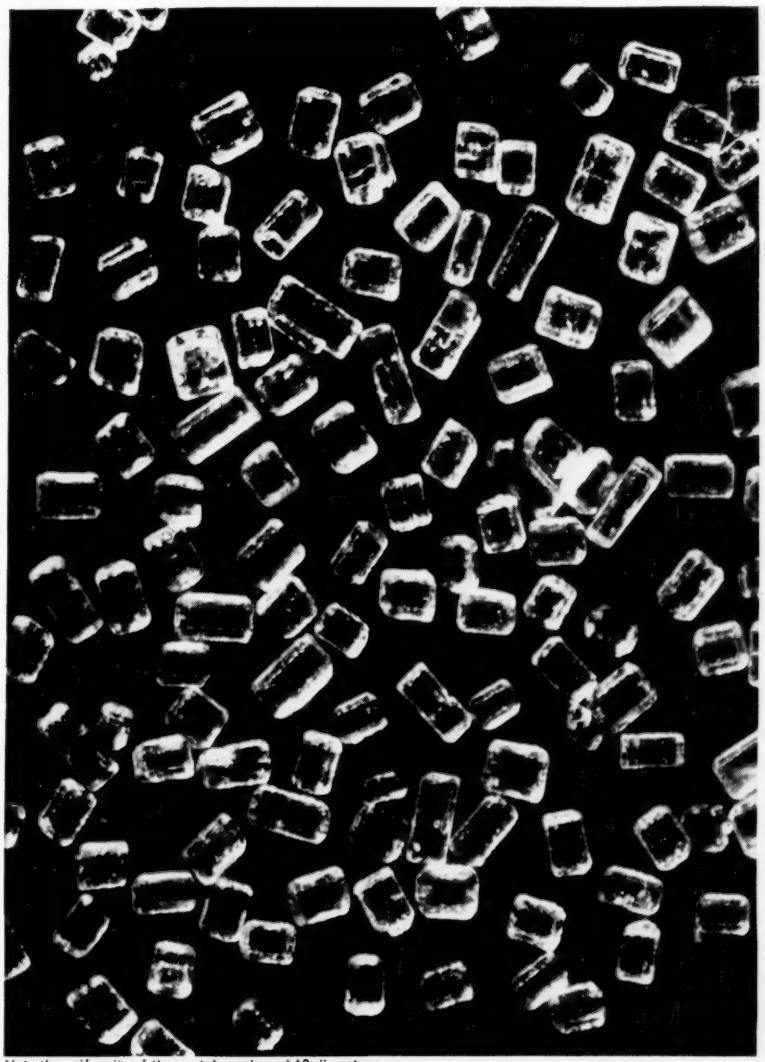
Here's what it means to you –

Ordinary commercial Ammonium Sulfate is a by-product material. B&A *Purified* Ammonium Sulfate is not. It is produced by B&A from carefully selected raw materials . . . manufactured to rigid specifications.

Compare our typical analysis below with the Ammonium Sulfate you are now using. You'll see that B&A Purified Ammonium Sulfate is extremely low in iron, lead and arsenic, thus providing superior quality for high purity end products. Also, its crystals are highly uniform in size, and it flows freely.

This extra "B&A Quality" can be worth much more to you than the difference in cost over ordinary by-product Ammonium Sulfate. For example—due to its low iron content, B&A Purified Ammonium Sulfate results in added luster and more even dyeing of wool and nylon . . . also gives greater dye exhaustion than ordinary commercial grades.

To make the best, you have to *use* the best. Specify B&A Purified Ammonium Sulfate.



Note the uniformity of the crystals—enlarged 10 diameters.

B&A AMMONIUM SULFATE, PURIFIED

Typical Analysis:

Assay $(NH_4)_2SO_4$	99.5	%
Insoluble	0.005	%
Residue after Ignition	0.01	%
Chloride (Cl)	0.001	%
Phosphate (PO_4)	0.001	%
Arsenic (As)	less than 0.00005	%
Heavy Metals (as Pb)	0.0002	%
Iron (Fe)	0.0005	%

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Fine Chemicals

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practice—especially in non-coal applications—is to saturate the nitrate with diesel oil.

Calaveras Cement Co., San Andreas, Calif., last month reported these figures for a typical quarry blast: 20,720 lb. ammonium nitrate, 2,007 lb. diesel oil and 2,450 lb. gelatin dynamite was used in nineteen 10-in. holes to move 64,900 tons of rock. Total cost, including labor, was $1,856. Cost of explosives amounted to 6.68¢/lb.; conventional explosives would have cost 19.7¢/lb. Calaveras is using 1 million lb./yr. of ammonium nitrate.

Amis Construction Co. tells *CE* that ammonium nitrate-diesel fuel blasting has helped put a $1.8-million Colorado highway project 12% ahead of schedule, besides effecting major economies. The firm contrasts delivered cost of $90/ton nitrate with $443/ton blasting gelatin. Powder factor—pounds of blasting agent per cubic yard of material to be moved—is about the same for ammonium nitrate as it is for conventional blasting agents, says Monsanto (other experts disavow this claim).

Blasting techniques vary among different operators, but are basically quite simple. You can pour prilled ammonium nitrate fertilizer directly into the hole, dousing it with diesel fuel as it tumbles in. A single stick of dynamite about two-thirds the way down the hole may be sufficient to detonate the charge.

Limitations of the new blasting method: It is not permissible underground, and it can't be used with wet holes.

Paper membrane is key to cheap water

Some 3.6 million gal./day (15,000 tons) of urgently needed fresh water will pour from the world's first large-scale electrodialysis plant sometimes this year. Located in South Africa's Orange Free State gold fields, plant will desalt 3,000 ppm. (95% NaCl) brackish water to 500 ppm. NaCl content.

Cost is predicted to be 29¢/-1,000 gal. of desalted water, assuming 9-mo. membrane life, 0.5¢/kwh. a.c. power, 6.5% interest, 15-yr. amortization. Cost breakdown shows 2.5¢ for pretreatment of water, 23.8¢ for electrodialysis and 2.7¢ for bulk distribution.

While these costs are based on extensive pilot trials, they must be proved out in large-scale operation. Granted continuing success, up to 45-50 million gal./day of water may be desalted this way by 1966.

Plant will use parchmentized paper membranes that cost only 10-20% as much as other commercially available types. Anion-selective membranes incorporate products of the polycondensation of guanidinium compounds with formaldehyde; cation-selective ones are based on alkaline condensation of the alkali salts of either phenol-sulfonic or p-cresol-sulfonic acid with formaldehyde. Both types rely on chemical reaction between these substances and the cellulose of the parchmentized paper base.

The two dialysis stages each consist of four dialysis presses with ten 200-membrane-pair packs in each press. Total membrane area is 272,000 sq. ft.

Acetylene processes: New and improved

Prospective producers of acetylene shopping around for available processes now have two more to pick from.

Tennessee Eastman, having revealed technical details of its new hydrocarbon pyrolysis process at the Chicago AIChE meeting last month, is now developing licensing arrangements which will be disclosed at a later date.

Meanwhile, M. W. Kellogg has declared its entry into the acetylene picture via the SBA partial-oxidation process (*Chem. Eng.*, Oct. 1957, pp. 144-6). During the past year, SBA and Kellogg engineers have come up with process improvements available in U. S. and U. K. only through Kellogg.

Eastman's process is significantly different from partial-oxidation and cyclic-regenerative process. Preheated fuel is burned in preheated oxygen (or air) mixed with steam to produce a flame temperature of 2,000 C. or higher. Hot gases pass through a venturi, into which the feedstock (e.g., propane, natural gasoline) and steam are injected. Mixture passes through a reaction zone, thence into a water spray for rapid cooling.

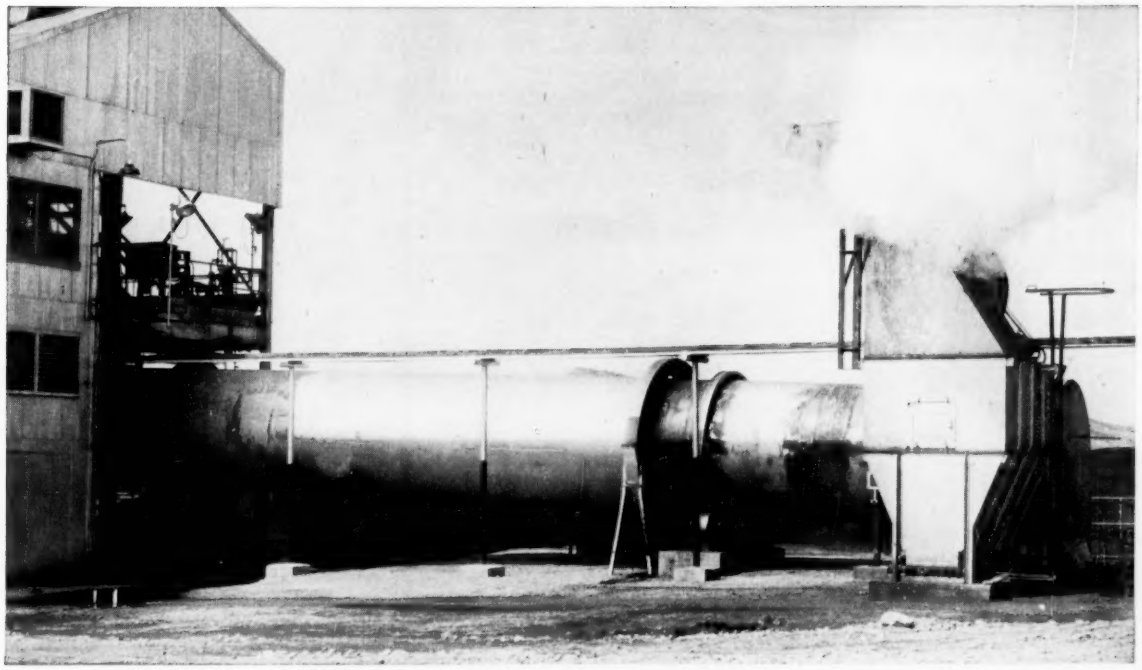
Eastman has carried out pilot operations on a 1-million-lb./yr. scale over a 12-month period. A furnace built of stabilized zirconia refractories was in good condition after 100 days' service.

Acetylene—and coproduct ethylene—were recovered via Hypersorption and selective absorption. Conversions to acetylene plus ethylene of 56 wt. % were obtained from propane. Conversions to acetylene alone of 45% were obtained with only a slight sacrifice in total conversion. Both air and oxygen were satisfactory oxidants.

For more on DEVELOPMENTS.....60

HELPING OTHERS PRODUCE A BETTER PRODUCT...

STANDARD HERSEY DRYERS



American Gilsonite's STANDARD cooler in operation at Grand Junction, Colorado.

GILSONITE TO GASOLINE... STANDARD STEEL SUPPLIES COKE COOLER FOR FIRST COMMERCIAL PLANT!

Standard Steel Corporation designed and built the rotary coke cooler now in operation at American Gilsonite's new refinery at Grand Junction, Colorado. This refinery, the first of its kind in the country to convert gilsonite into gasoline on a full scale commercial basis, uses an 8 ft. by 80 ft. coke cooler in the process. It's another cooler *Job-Engineered* by Standard Steel Corporation! A specially designed "floating inner jacket" protects the outer shell... and a water cooled feed and chute pre-cools the coke. Here is another fine name added to the long list of prominent, satisfied users of STANDARD STEEL rotary processing equipment.

Designers and Manufacturers of

ROTARY DRYERS
KILNS—COOLERS
CALCINERS
HEAT EXCHANGERS
...AND OTHER PROCESS EQUIPMENT

IF YOU HAVE A PROCESSING PROBLEM!

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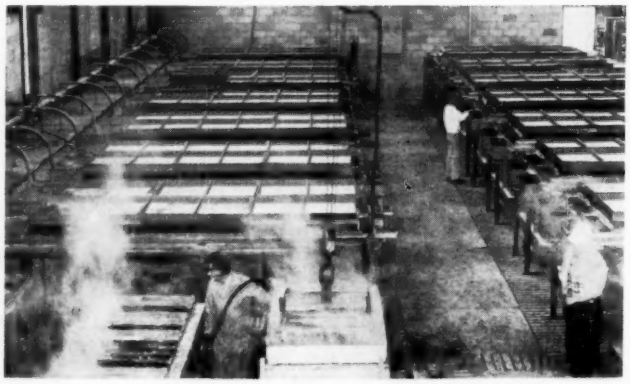


Firm Converts to Electrolytic Cobalt Route

Conventional electrolytic cells, above, represent the hope of Calera Mining Co. to lower costs and boost output of cobalt at its Garfield, Utah, plant. Firm is the only one to convert from newer hydrogen-reduction process, probably because of specific purification problem. It expects 4-5% boost in cobalt output.

More U-Mills Slated Despite AEC Hesitation

In spite of a recent Atomic Energy Commission decision to limit approval on any new contracts for purchase of uranium concentrates, uranium mill construction is rolling along unabated.

In the Ambrosia Lake bonanza near Grants, N. M., Homestake Mining Co. is erecting two mills. Larger mill—1,500 tons/day capacity—using a carbonate leach system will be completed in June at a cost of $10 million. Smaller 750-ton/day mill also uses a soda ash leach. This $5-million plant is slated to be in operation by February.

Phillips Petroleum is also building a $9.5-million mill in the Grants area.

Construction has started on Fremont Mineral's new 500-ton/day mill at Riverton, Wyo. Plant will feature two parallel leaching circuits: An acid leach for low-lime ores and carbonate leach for high-lime ores found in some areas of Wyoming. The two circuits will feed into common final processing stages where uranium will be recovered by solvent extraction.

And Lakeview Mining Co. has announced plans for a 210-ton/day mill at Lakeview, Ore. Final design of the $2.6-million mill has not been completed yet, but it will employ a solvent extraction uranium recovery system.

Expanded Rubber Plant Uses Continuous Route

In boosting synthetic latex capacity to 27,500 tons/yr. at its Akron, Ohio, plant this winter, Goodyear Tire & Rubber Co. features, for the first time, a commercial process for continuous polymerization of high-solids latex.

Continuous route called for addition of 10 glass-lined reactors with a capacity of 3,750 gal. each and two butadiene and two styrene recovery columns. Cost of the expansion is $2.75 million.

Although Goodyear is close-mouthed about new equipment and operating conditions, this much is known: Reactors represent the first successful use, on a commercial scale, of direct-expansion ammonia coils for cooling the reacting butadiene-styrene latex.

Lead Slag Gives Low-Cost Shield

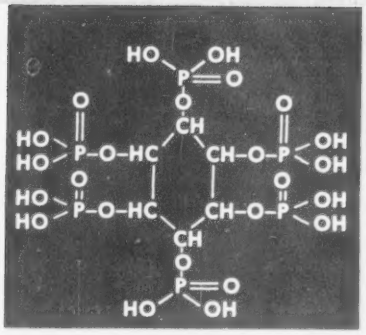
Capitalizing on some built-in site advantages, Applied Radiation Co., Walnut Creek, Calif., has demonstrated the possibility of constructing low-cost radiation housing. Arco used a ready source of lead ore slag plus underground construction to house an electron accelerator for only $54,000.

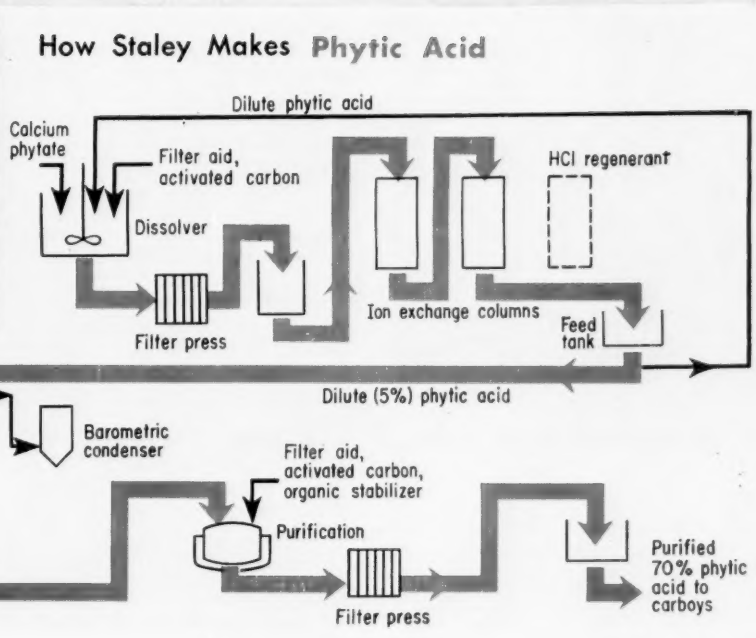
Using conventional construction methods, it would have cost $250,000-$500,000 to house the 30-kw., 50-mev. accelerator Radiation capacity of this unit is 2,000 lb./hr. of polyethylene at 12 megarad dosage. (One rad equals 100 ergs of absorbed energy per gram of absorbing material.)

Since amortization of fixed investment is largest single item in radiation processing economics, this substantial saving in cost of housing radiation equipment could mean the difference between profit or loss in a commercial venture.

Main saving came in shielding material used. From a smelter 30 miles away, ARCO obtained 270 tons of lead ore slag which ordinarily is a waste material. Mixing this slag with concrete, ARCO got shielding material for $17/cu. yd. compared with around $200 for concrete mixed with some other conventional high-density material like ferrophosphorous, barite or magnetite.

Too, soil conditions at Walnut Creek allowed ARCO to use underground construction which saved on wall thickness.





Ion Exchange Now Yields Phytic Acid

With novel acid recycle and ion exchange, Staley wrings new byproduct from waste corn steep liquor.

One of the soundest approaches to diversification is the development of new products—and markets therefor—from raw materials or waste streams already available within the framework of existing operations.

This route was chosen by A. E. Staley Mfg. Co., Decatur, Ill., for breaking into the fine chemical business. Latest entry bidding for commercial markets is phytic acid which, like its older sister products, calcium phytate and inositol, comes from corn steep liquor (CSL).

With tremendous quantities of CSL available from its corn processing operations, Staley is now operating a new pilot plant for turning out carboy quantities of 70% phytic acid solution. Process involves use of ion exchange in a novel flowsheet.

▶ **Where Do They Come From?**—Production of these three related chemicals is derived from phytin, a mixed salt of phytic acid containing calcium and magnesium as predominant cations. Approximately 4% of the total solids present in CSL are phytin (about 0.4% based on composition of dilute steep water).

Taking them in reverse order of their appearance in the process: Inositol is the commercial name for cyclohexane hexol, i.e., cyclohexane with a hydroxyl group at every position. Phytic acid is the hexaphosphoric acid ester of inositol (see structural formula above). Calcium phytate is the hexacalcium salt of acid.

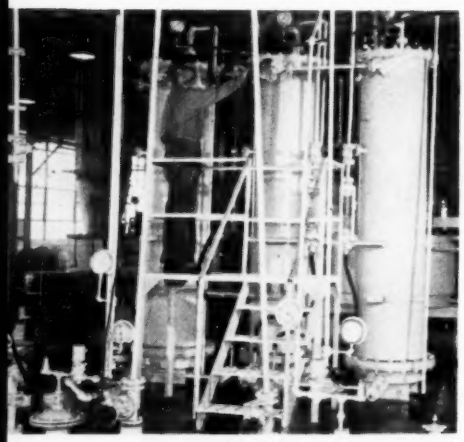
▶ **Where Do They Go?**—Uses of phytic acid capitalize on its reactions with heavy metals, especially iron.

Chief commercial use turned up so far is based on its rust-inhibiting action. Two leading food processors are both using 0.01% phytic acid in the hot-water baths for sterilizing jars of baby foods. It prevents rusting of the otherwise unprotected edge of the stamped-out jar lids.

Staley also looks for major uses of phytic acid in surface treatment of metals. Such treatment (which may be likened to phosphatizing, in view of phytic's phosphoric acid content) is said to facilitate plating and improve the adhesion properties of metal for the application of protective coatings.

Other possible uses involve phytic acid's ability to sequester metal ions. For example, Staley is looking into use of phytic in its own soybean oil refining operations, where it would sequester trace metals and give a premium-grade oil.

Calcium phytate, too, serves as



ION EXCHANGE columns convert calcium phytate to phytic acid.

a sequestering agent in food products, such as vinegar and maraschino cherries. It is also used as a source of calcium in pharmaceutical preparations. And inositol, a recognized member of the B-complex group of vitamins, also finds its chief markets in the pharmaceutical field.

▶ **How Are They Made?**—First step in making these products is partial evaporation of CSL to a solids content of 20-25%. (Commercial CSL, sold to antibiotics makers as a microbiological nutrient, contains 50% solids.)

Treatment of CSL with calcium hydroxide throws down a crude calcium phytate which contains some denatured protein precipitated along with the phytate salt. To get a purer product, Staley redissolves the crude salt in hydrochloric acid and reprecipitates with lime.

For some purposes Staley makes a phytate salt low in Ca, retaining more of the original Mg and K content of the natural phytin. Precipitating with caustic soda instead of lime achieves this result.

▶ **Stewed in Own Juice**—First step in converting calcium phytate to phytic acid is to get it into solution. While this could easily be done with HCl, there would remain the problem of separating the phytic acid from $CaCl_2$.

Staley's trick is to avoid the introduction of the second anion by solubilizing calcium phytate with a recycle stream of dilute phytic acid. This converts the insoluble hexacalcium salt to a more-soluble lower calcium salt. Then the calcium ion is easily removed by acid-regenerated ion exchange resins.

Reference to the flowsheet shows how this is done. Initial reaction occurs in a rubber-lined steel vessel. Color bodies and other extraneous materials are removed by addition of activated carbon and filter aid, then passing the liquid through a Heresite-coated filter press into a Haveg holdup tank.

Ion exchange unit consists of three 2-ft.-dia. by 10-ft. rubber-lined steel columns, with two used in series at a time. Resin is regenerated with HCl.

▶ **Finishing Steps**—Dilute phytic acid (5%) from the ion exchange unit goes to a natural-circulation, long-tube evaporator made of Haveg, with 60 sq. ft. of Karbate impervious graphite tubes. Evaporator operates semi-continuously at 140 F. under 27 in. vacuum until the 200-gal. batch has reached a concentration of 70% phytic acid. This usually requires about 8 hr.

Concentrated solution is further purified with adsorbents in a glass-lined vessel. It also gets a shot of a special unidentified organic agent as a stabilizer.

Product is bottled in 70-lb. glass carboys.

Piping in contact with phytic acid is of glass, solid saran or saran-lined. Valves are of the diaphragm type, using rubber.

New Etching Route Boasts Economy, Process Pluses

A new process for etching printed circuits, developed by Becco Chemical Div., Food Machinery & Chemical Corp., uses an aqueous ammonium persulfate solution to etch all types of conventional boards and laminates, boasts several advantages and operation at least as economical as the more common chromic-acid or ferric-chloride processes.

Becco process, which can be carried out in conventional etching equipment using tank-immersion or spray techniques, lists these pluses:

- Etchant is relatively noncorrosive. Persulfate solution is compatible with most nonmetallic materials, including many plastics (but not natural rubber). Type 304 or 316 stainless steel is recommended, though aluminum can be used under some conditions.
- Since only water-soluble reaction products are formed, sludge formation is avoided. Etched boards can be cleaned easily with a water rinse.
- Waste removal is easy and copper may be recovered from spent persulfate solution. Copper may be plated out electrolytically and mother liquor, after dilution with water, can be sewered without further treatment in most localities.

▶ **Spray or Immersion?**—Conventional spray or paddle etchers hold 10-20 gal. of etching solution, but etch only one board at a time, inefficiently exposing a small copper area to a large solution volume. To improve these economics, what's needed is temperature control and equipment modification to reduce the amount of etching solution in the machine.

When using immersion technique most economical operation is to load the tank so that about 2 sq. ft. of 1-ounce board for each gal. of tank content are immersed at one time. This means splitting theoretical copper load of about 8 oz./gal. into four separate loads.

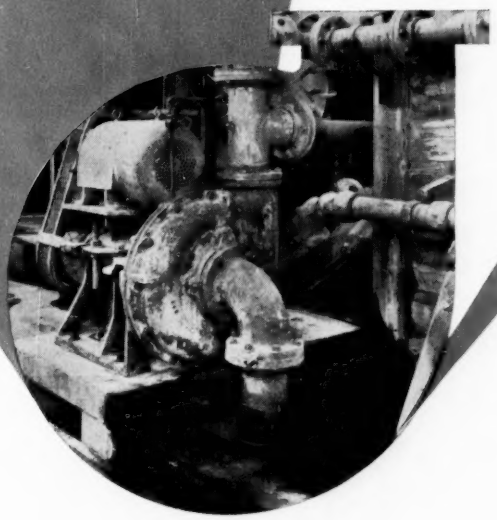
▶ **Temperature Is Key**—Etching rate and process economics are determined mainly by bath temperature and agitation. Dissolving ammonium sulfate consumes heat, whereas etching process produces heat.

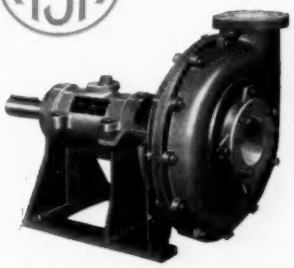
Becco recommends starting the process at about 70 F., or slightly above, and holding bath temperature to not much above 170 F. High temperature accelerates etching reaction, but too high temperatures reduce ammonium sulfate stability.

Condition of the solution can be controlled merely by checking pH. Freshly made up solution (2-2.5 lb. ammonium sulfate per gal. of tap water) has a pH above 4, while exhausted solution shows pH of about 1. For best results, end pH should be determined by test runs.

Pump them ECONOMICALLY EFFICIENTLY

Those nasty corrosive slurries





Except for the impeller and engine-side shell half-liner, the Centriseal Slurry pump is identical with the Hydroseal Slurry pump. Made in seven sizes: 2″ to 14″, for pulp from 400 to 8 mesh.

The Centriseal Slurry pump handles abrasive, corrosive pulp with dependable efficiency and economy. All wearing parts are moulded of Maximix rubber or neoprene, both of which outlast metal many, many times. When a wearing part does succumb, it is cheaply and easily replaced. And, the metal parts around the stuffing box may be specially made of corrosive-resistant materials. Furthermore, the stuffing box, shaft sleeve and gland are protected — not by sealing water, but by the action of auxiliary vanes of the impeller, enabling the Centriseal to deliver pulp undiluted.

Write for illustrated BROCHURE No. 557

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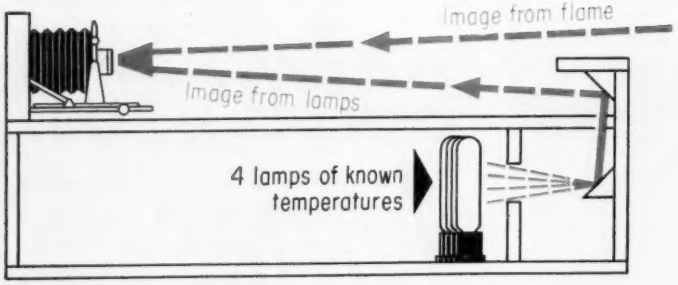
Dept. C—259 E. Lancaster Ave., Wynnewood, Pa.
Representatives throughout the World

CENTRISEAL and HYDROSEAL
SAND, SLURRY & DREDGE PUMPS
MAXIMIX RUBBER PROTECTED

Camera records light from reference lamps and flame on same film



Film Tells Flame Temperature

Photographed at same time as unmeasured flame, images of standard reference lamps provide built-in calibration for determining flame temperature.

Now, thanks to some simple tricks with photographic pyrometry, engineers can measure accurately flame temperatures from pictures without worrying about the extremely close control of exposure and development usually needed for quantitative analysis of photographs.

Photographic measurement is attractive because it records radiation from the entire flame at any given instant. But it's difficult to correlate image densities on developed film with object intensities without close control of the many variables in the photographic process.

Researchers F. S. Simmons and A. G. DeBell of North American Aviation's Rocketdyne Div., Canoga Park, Calif., have now come up with a new technique—accurate within 10 deg. between 1,000 C. and 2,000 C.—which, in effect, gives every picture its own calibration curve.

▶**How It Works**—Key to the method lies in photographing, along with the object of interest (jet flame in this case), a set of four standard comparison lamps whose brightnesses and known temperatures span those of the object. For each picture, then, the standard lamps would furnish data for a film density-temperature curve. Film density of the object, and its corresponding temperature, lie somewhere on this curve.

With this method, it's necessary only to make sure (for reproducible precision) that image densities lie somewhere on the straight portion of the familiar log exposure-film density curve published by film makers.

To determine film densities, Simmons and DeBell use an unbalanced-type photoelectric densitometer with an effective field on the order of 1 mm. in diameter.

▶**Photographic Setup**—Sketch above shows the photographic setup. Camera's field of vision includes direct light from the rocket flame and light reflected by two first-surface mirrors from tungsten-filament comparison lamps set behind field lenses. These lenses are adjusted so that images of lamps and rocket flame can be brought into common focus by the camera.

The conventional 4X5 camera is equipped with 127-mm. and 208-mm. lenses and between-the-lens shutters with solenoids for remote operation. Different filter combinations pass light of either 0.45-micron or 0.65-micron wave length.

▶**Prism Reflects Radiation**—To use the two-path-length method (explained shortly, see box for basic formulas), it's necessary to have a source of reflected radiation from the flame.

Simmons and DeBell mount a corner-reflecting prism (of reflectance 0.74 at 0.65 microns) behind the flame. The camera sees the prism as a bright spot in the jet exhaust. This prism gives the two-path intensity from which two-path temperature is determined. Single-path inten-

Basis for True-Temperature Equation

Intensity of single-path radiation is given by Wein's equation:

$$J_s = \epsilon_\lambda c\lambda^{-5} e^{-b/\lambda T}$$

And for double-path intensity:

$$J_d = \epsilon_\lambda \left[1 + R_\lambda (1 - \epsilon_\lambda)\right] c\lambda^{-5} e^{-b/\lambda T}$$

From which we obtain:

$$\epsilon_\lambda = 1 - \left(\frac{1}{R_\lambda}\right)\left(\frac{J_d}{J_s} - 1\right)$$

To arrive at an equation for true temperature independent of emittance, we substitute this value in the equation which gives relationship between true and apparent temperature:

$$\frac{1}{T} = \frac{1}{T_a} + \frac{\lambda}{b} \ln \epsilon_\lambda$$

and arrive at the two-path-length, true temperature equation:

$$\frac{1}{T} = \frac{1}{T_a} + \frac{\lambda}{b} \ln\left[1 - \left(\frac{1}{R}\right)\left(\frac{J_d}{J_s} - 1\right)\right]$$

Our nomenclature: J_s and J_d are single and double-path intensities in watts/cm.²-micron, ϵ is emittance at wavelength λ, b and c are constants, R is prism reflectance at λ, T and T_a are true and apparent temperatures in deg. K.

News from
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E. S. Malkin is typical of the thoroughly trained and widely experienced sales engineers representing National Carbon Company to the chemical processing industries. Mr. Malkin graduated from Lehigh University with a B.S. in chemical engineering. He spent four years in National Carbon's new products development group, originating designs and developing new equipment. For ten years he has been a field engineer.

Mr. Malkin is qualified to aid in the selection, special designing and installing of carbon, graphite and "Karbate" chemical process equipment. Call your "National" Sales Engineer today . . . he can save you time, money and needless worry.

NOW..."Karbate" Armored Pipe In Larger Sizes

"Karbate" armored pipe is now available in 3 larger sizes – 6″ I.D., 8″ I.D., and 10″ I.D. – all with slip-on cemented type fittings.

Since its recent introduction, "Karbate" armored pipe has gained wide acceptance throughout the industry. For example, a recent insecticide plant installation utilized large quantities of 3″, 4″, 6″ and 8″ piping.

As in the case of the smaller sizes up to 4″, the 6″, 8″ and 10″ "Karbate" armored pipe and fittings are available for prompt deliveries.

CORROSION RESISTANT CARBON & GRAPHITE TOWER INTERNALS ASSURE MAXIMUM OPERATING EFFICIENCY

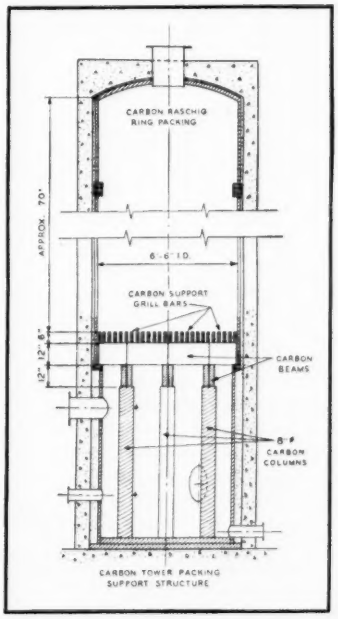
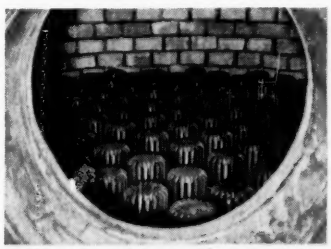


Diagram of a typical carbon tower packing support structure.

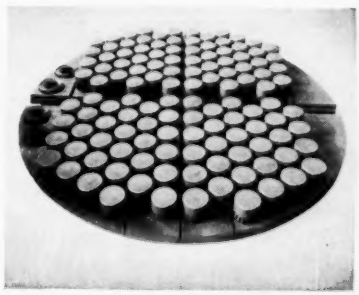


"Karbate" plate-type tower packing support installed in a primary phenol stripping column. Here the slotted cap design increases the free area.

Carbon, graphite and "Karbate" Impervious Graphite packing support structures, bubble cap trays and sieve trays are used by major oil and chemical companies in applications such as: *caustic scrubbing towers – ethyl alcohol (sulphuric alkylation) stripping towers – anhydrous HCl stripping towers – carbon dioxide absorption towers* (pulp and paper mills).

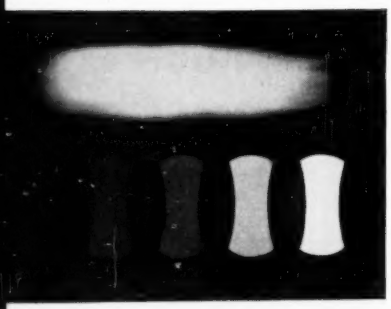
Even after years of operation, the design efficiencies of these tower internals have remained at a high level because of no formation of corrosion products.

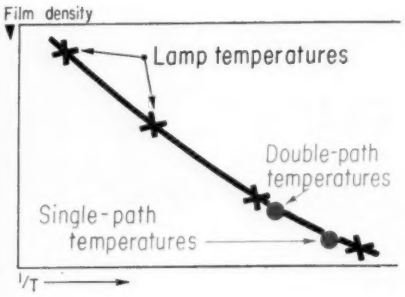
Carbon and graphite internals can be subjected to temperatures of several thousand degrees (F) without distortion or loss of strength. In addition, rapid changes of temperature will not cause thermal shock failure. In operating temperatures up to 340 degrees, "Karbate" internals can be used with a reduction in dimensions. This is due to the increased strength this material offers over plain carbon and graphite. **Request Catalog Section S-7340.**



"Karbate" bubble cap tray installed in a secondary phenol stripping column. 10′ diameter tray having 124-4″ I.D. bubble caps. 10 such trays are installed in the column.

PICTURE gives image densities of lamps and flame, which, when plotted vs. known lamp temperatures, show single and double-path flame temperatures.





sity is measured from the immediate flame area surrounding this bright spot.

▶**Why Two-Path Method?** — Since optical pyrometers are calibrated in terms of black-body conditions (perfect radiator, emittance of 1), intensity measurements on non-black sources give an apparent or brightness temperature lower than the actual temperature (see box). This is because radiation intensity from a non-black source is ϵ_λ times the intensity from a black body at the same temperature.

If emittance of the flame were known, it would be simple to find true flame temperature by comparing flame-image density, representing apparent flame temperature, with lamp-image densities, representing known true temperatures. But it's not so easy because flame emittance is a function of flame composition, temperature, thickness and wave length.

Here's where the prism, showing reflected or double-path intensity, comes in. Knowing the intensities for a single and double traversal of the flame, you can solve for flame emittance in terms of these intensities and prism reflectance (see box).

Brightness temperature in the formula is brightness temperature of the flame, and the two intensities correspond to "brightness temperatures" for a single and double traversal of the flame.

▶**Some Refinements** — Now we have all the data we need to find true flame temperature.

Rocketdyne researchers, however, have polished up the technique to make the job easier and more accurate.

Since λ is a constant, the quantity $e^{-C_2/\lambda T}$ may be substituted for the J's in the final equation. Solving the equation is made easier by semilog plots of $e^{-C_2/\lambda T}$ vs. 1/T.

Too, calibrating the comparison lamps in place, with the optical pyrometer lens replacing the camera lens, eliminates corrections for lens transmittance and mirror reflectance.

And, although a plot of film density vs. temperature would be valid, Simmons and DeBell gain accuracy in interpolation by plotting film density vs. reciprocal temperature.

▶**Further Problems** — While Rocketdyne researchers are encouraged by results of tests to date, they see some areas where a lot of work can be done.

To apply this method to heterogeneous flames, flames of varying temperature and luminous particle density, Wien's equation must be used in integral form. For this purpose, further studies would have to establish carbon-particle density profiles in relation to gradients in flame temperature and luminosity.

Moreover, since flame emittance varies with engine size and carbon content of the exhaust, experiments might include surrounding a small engine with nitrogen to eliminate the luminous mantle.

Finally, the instrument itself could stand some refinements. Simmons and DeBell will install high-quality field lenses to cut down distortion of lamp-filament images. And a recording microdensitometer would improve precision and make data reduction easier.

Convention Calendar

Canadian Pulp & Paper Assn., Technical Section, annual meeting, Sheraton-Mt. Royal Hotel, Montreal, Que., Jan. 29-31.

Instrument Society of America, symposium on chemical and petroleum instrumentation, Hotel DuPont, Wilmington, Del., Feb. 3-4.

Society of the Plastics Industry, 13th Reinforced Plastics Div. Conference, Edgewater Beach Hotel, Chicago, Ill., Feb. 4-6.

Instrumentation and Control in the Process Industries Conference, sponsored by Armour Research Foundation, Hotel Sherman, Chicago, Ill., Feb. 6-7.

American Society for Testing Materials, annual meeting, Hotel Statler, Boston, Mass., Feb. 10-14.

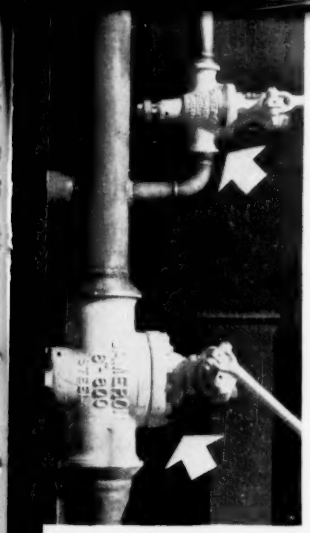
National Society of Professional Engineers, spring meeting, Michigan State University, East Lansing, Mich., Feb. 13-15.

Technical Assn. of the Pulp & Paper Industry, 43rd annual meeting, Commodore Hotel, New York, N. Y., Feb. 17-20.

National Council for Stream Improvement, annual meeting, Waldorf-Astoria Hotel, New York, N. Y., Feb. 17-20.

Chemical Institute of Canada, 12th divisional conference, Protective coatings Subject Div., Toronto, Ont. (Feb. 20) and Montreal, Que., (Feb. 21), Feb. 20-21.

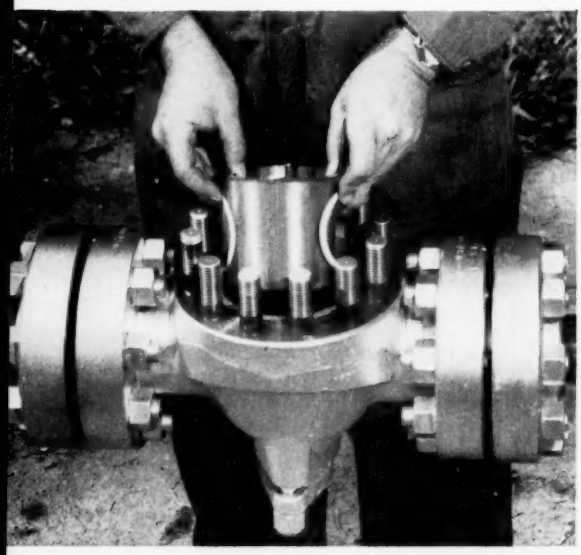
American Society of Mechanical Engineers, Gas Turbine Power Div., conference and exhibit, Shoreham Hotel, Washington, D. C., March 3-6.



SMOOTH DESIGN

The sealing surfaces of Cameron Non-Lubricated Lift-Plug Valves are smooth—so smooth they require no greases, no expensive lubrication program to maintain a perfect seal. They close bubble-tight on today's elusive, high pressure fluids and gases.

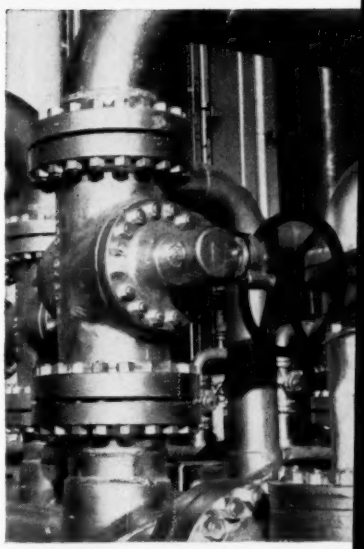
The unusual Cameron Lift-Plug design eliminates friction because the plug is lifted from the seat before rotating—actually never touches the seat except when completely open or closed. Unlike ordinary valves, Lift-Plugs employ a removable seat which is sealed off from the body and will not reflect pressure distortions. As an added benefit, this makes possible special trims for a wide range of services and temperatures — stainless steel for corrosives, Hycar for LPG, etc.

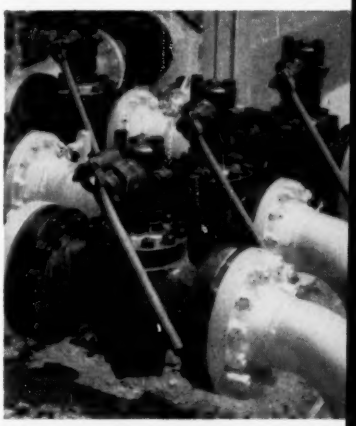


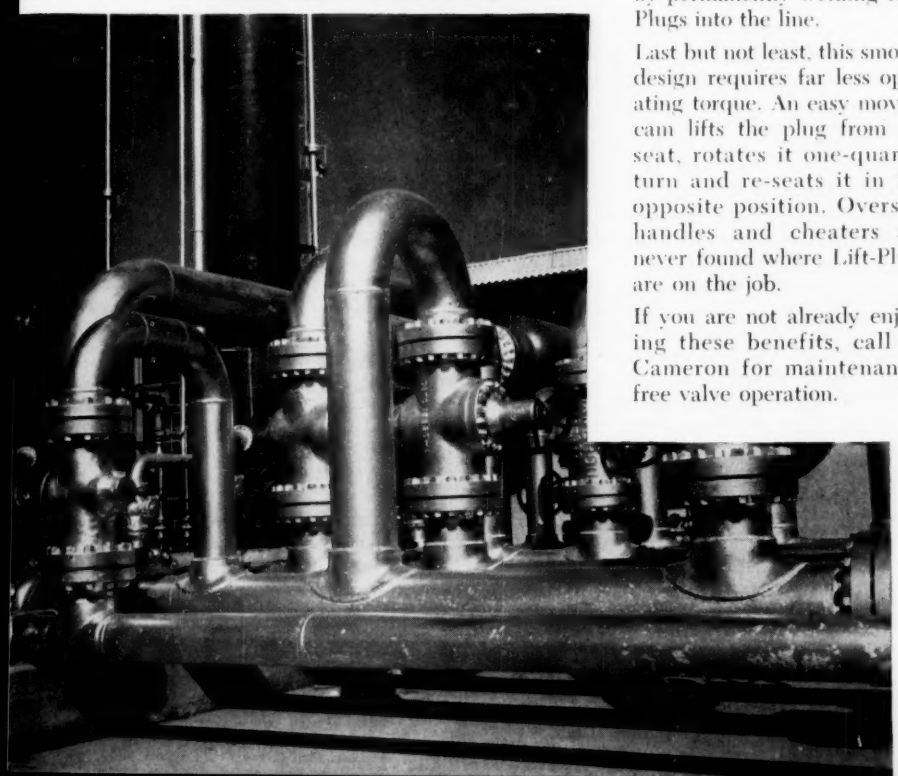
When repairs are finally necessary the seat and plug may be easily replaced without removing the valve from the line. Flanges and connection leaks can be eliminated by permanently welding Lift-Plugs into the line.

Last but not least, this smooth design requires far less operating torque. An easy moving cam lifts the plug from the seat, rotates it one-quarter turn and re-seats it in the opposite position. Oversize handles and cheaters are never found where Lift-Plugs are on the job.

If you are not already enjoying these benefits, call on Cameron for maintenance-free valve operation.







Cameron

IRON WORKS, Inc.

P. O. Box 1212 — Houston, Texas

Export Office: 7912 Empire State Bldg., New York City. In England: Cameron Iron Works, Ltd., Time & Life Bldg., New Bond Street, London W. 1 England

Dispatcher smooths fork-truck movement.

Radio Scores Assist in Materials Handling

Revamped materials movement serves stepped-up production at a fine-chemicals plant. Helping: A mobile two-way radio network, noteworthy by its smallness.

At J. T. Baker Chemical's Phillipsburg, N. J., plant, a new materials handling setup enables the company's receiving department to keep step with a 35% rise in plant output, without need for extra trucks or manpower.

Trains of trailers, loaded with palletized goods, move through the plant. Radio-assigned fork-lift trucks direct and service these trains. A Dempster-Dumpster unit does, among other things, a yeoman job of waste disposal; it distributes some two-dozen containers about the plant area, picks them up on schedule, hauls them to a dump two miles away.*

Coordinator of all this, and more, is a centralized materials handling dispatcher. This dispatcher monitors the flow of raw materials, intermediates, finished goods and container components within the plant.

* This one vehicle replaced Baker's three dump trucks and released five of the six original truck men for other duties in the plant.

▶ **Enter 2-Way Radio**—One of his aids is mobile, two-way radio, which he uses to smooth movement of fork-lift trucks. It was this radio setup—and its small size — which especially caught our eye when we visited Baker.

For mobile two way radio is an unusual and little-appreciated tool for materials handling in a plant of this size.

RCA people say Baker's radio installation—a 3-w. base station and mobile units on four fork-lift trucks—is just about the smallest industrial job they have handled. Cost: Less than $4,000.

Baker hopes now to install mobile units on four more fork-lift trucks, two flat-bed trucks and the Dempster unit. Yet even with this expansion, total radio-controlled materials movement will still be modest by present-day standards.

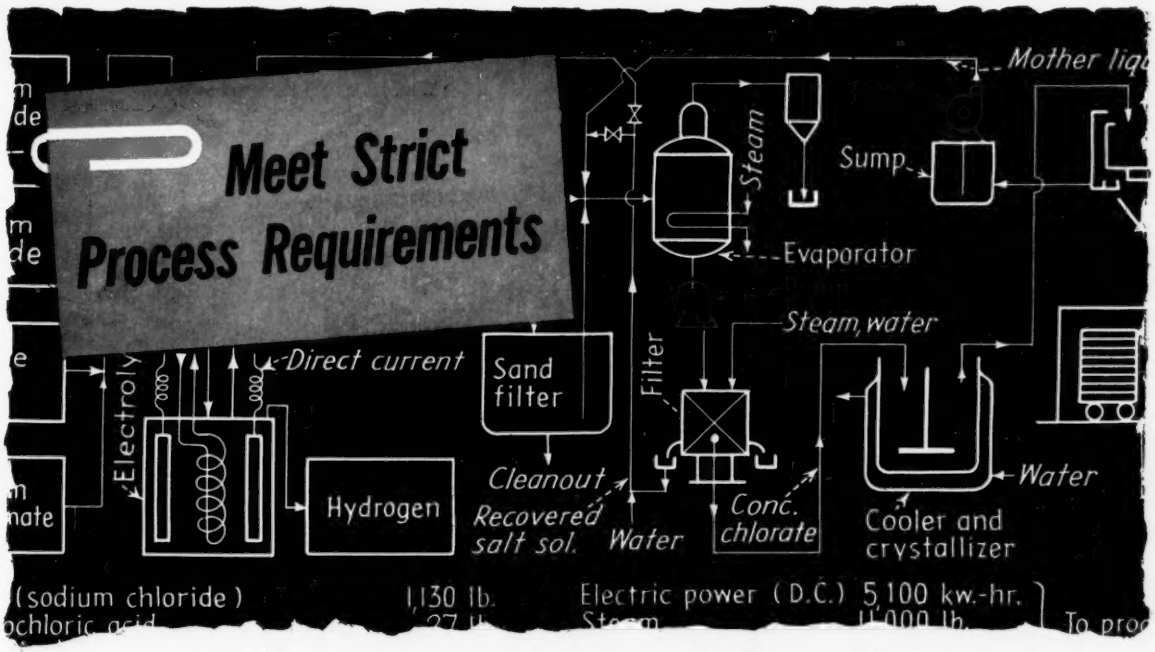
Modest or not, the system is paying off. Baker's wish to invest in more equipment attests to this.

▶ **Tightens Purse Strings** — Baker's satisfaction with its radio setup verifies what materials handlers long have claimed —that as soon as your vehicles are out of sight, regardless of distance, you'll find that they operate less efficiently without direct communication; that if you operate handling equipment on non-repetitive work through several departments or into outdoor areas without direct communication, you lose money on the arrangement.

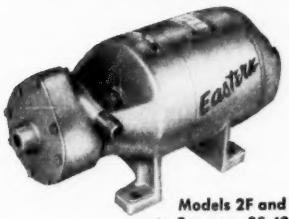
Assuming that this claim is true, it's not hard to see how Baker gets its money's worth. In the course of one year, the company produces about 500 different chemicals within its 40-odd acre plant site; at any one time there may be 100-150 of these moving around in various stages of manufacture.

Compound this diversity with the myriad packages for these chemicals—from 55-gal. drums to 1-oz. bottles—and you've got a sweet problem in materials movement.

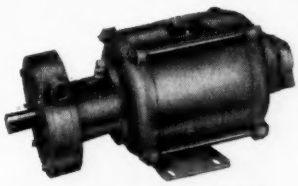
▶ **What Baker Selected**—Faced with this type of materials handling job, Baker decided its needs would be met best by operating via the rather new FCC-licensed



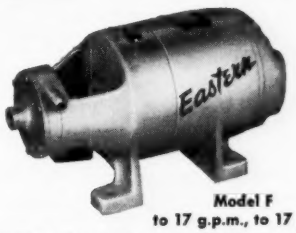
. . . with Eastern Centrifugal Pumps



Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.

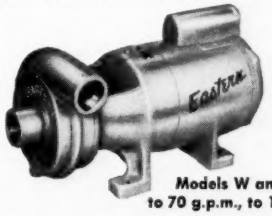


Model D-11
to 7.5 g.p.m., to 18 p.s.i.



Model F
to 17 g.p.m., to 17 p.s.i.

Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.



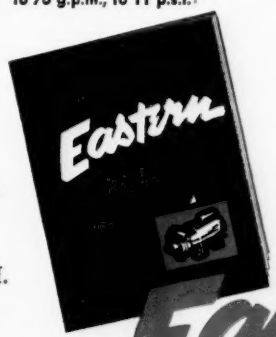
Models W and Z
to 70 g.p.m., to 11 p.s.i.

Models 3F and 3J
to 5 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.



NEW EASTERN CATALOG

Eastern Centrifugal Pump Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 110F.

Eastern

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low-power industrial service. Available to anyone with a legitimate business, this class affords limited power (3-w. input), limited range (about 1 mile) and little privacy since all low-power licensees use 154.57-mc. frequency.

For intraplant control in uncongested areas up to 25 acres, with little topographical interference,* this arrangement is very satisfactory. And it's low cost, to boot.

▶ **Big Boy's Place** — Higher power and more privacy are available in other frequency ranges, in what is called special industrial service. Baker didn't feel, though, that its particular requirements justified the extra cost—or the red tape involved in getting FCC clearance. (To get special industrial service, you have to prove low power's inability to meet your needs.)

One rule of thumb: Special-industrial-service equipment in the 150-mc. range runs about 33% higher than low-power equipment; in the 450-mc. range almost 100% more.

For the most part, you'll find special-industrial-service equipment in larger plants in the chemical field as well as in steel mills, oil refineries, shipyards and mines.

In the main, larger chemical plants combine control of materials handling with things such as plant protection, supervision and maintenance. Among these larger users you'll find Dow (Freeport), Olin Mathieson (Niagara Falls) and Columbia-Southern (Corpus Christi) to name a few.

A major reason why smaller plants are reluctant to adopt two-way radio is that there's been real doubt that radio dispatch can be a full-time job. But when you combine the functions of radio dispatcher and materials-handling coordinator, as did Baker, you overcome this objection.

In fact, radio simply won't work most effectively for any plant where management can't agree on a single point for order origin and assignment.

* The most famous example of the importance of non-interference was Sputnik I's ¼-w. beep-beep—heard across a 600-mile span of space.

Blonde Tresses For Nitrogen Fixation

Glass fibers containing U-235 oxide and resembling a woman's crowning glory have been developed for nitrogen fixation by two Rensselaer Polytechnic Institute physicists, Paul Harteck and Seymour Dondes.

When heated compressed air is exposed to these fibers, nitrogen dioxide is formed by fission-energy release.

Initially, nitrogen was fixed using finely divided U-235 oxide powder. But researchers found that incorporating the oxide into glass fibers made more energy available and increased efficiency of reaction.

These fibers, which can be incorporated with thorium or plutonium as well, may also be used in future atomic reactors. Stability of these "atomic" fibers is greater than metallic fuel elements presently in use. Too, they are easily fabricated and readily processed to recover unused uranium.

Owens-Corning Fiberglas Corp. co-operated in the development.

India Shows Gain in Chemical Technology

India's engineers and scientists are making valuable contributions to that country's drive for industrialization.

Bombay University's Chemical Technology Dept. claims a new method for recovering nickel from spent catalyst used in fat hydrogenation. Nickel is in critical supply in India.

Spent nickel catalyst is dissolved in slight excess of sulfuric, nitric or hydrochloric acid. Fat is removed by extracting with hexane. Then contaminating iron is oxidized with hydrogen peroxide and precipitated as ferric hydroxide. Sodium formate is added and nickel formate crystallized out in a monel evaporator.

More savings were chalked up when researchers at India's Sindri, West Bengal, fertilizer plant developed a fertilizer catalyst that can be manufactured for much less than the cost of imported catalysts.

And the Sindri center has developed an iron oxide desulfurization mass for oxidizing H_2S in plant off-gases. This product reportedly has three times the activity of imported products; it's being manufactured in a plant designed by Sindri engineers.

Too, India is engaged in a $22-million expansion of its urea and ammonium sulfate fertilizer plant at Sindri. Russia is aiding this program with $315,000 worth of equipment for technical research and the Italian firm of Montecatini is supplying technical assistance.

New Uranium Process Goes Into Pilot-Plant Stage

To test out a new electrolytic process (*Chem. Eng.*, July 1957, p. 158) for extracting uranium, a pilot plant with a 25-ton mill will be under construction at Monticello, Utah, early this year.

Two firms which have pushed development on the new process will be partners in the endeavor: American Miling Corp. and Atomic Resources Corp.

Electrolytic route, invented by Melvin E. Richards (now president of American Milling), involves passing current through a boiling-water slurry of crushed ore, depositing uranium metal on steel plates. Boiling the solution forces out troublesome gases, allowing uranium to deposit on electrode.

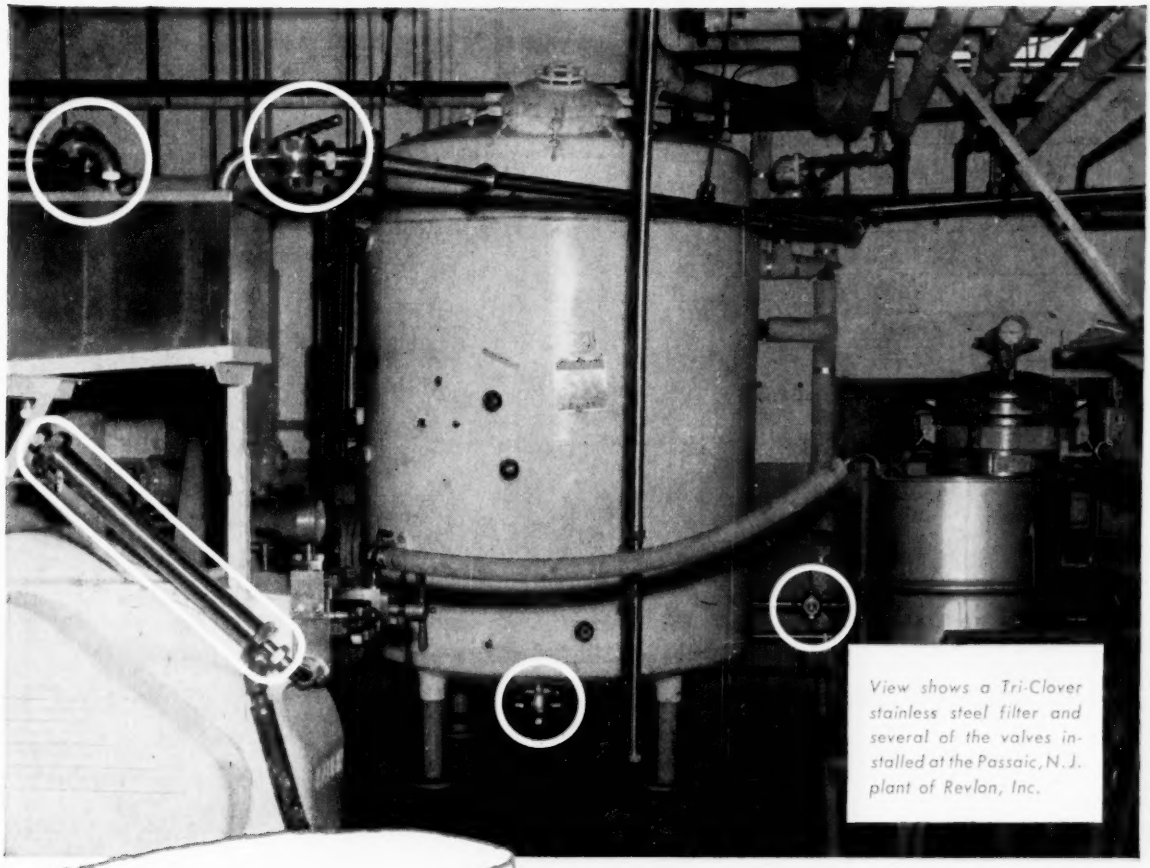
Dubbed the Yucca process, the route is reportedly 50% more efficient than present extraction methods.

Hydrometallurgy No Sure Path to Profit

Don't look to hydrometallurgy for an economic cure-all in mining and metals industry. Such was the warning given by F. A. Forward, of the University of British Columbia's Dept. of Mining and Metallurgy, in a paper given before the recent A.I.Ch.E. meeting in Chicago.

This restraining word was sounded as hydrometallurgy wins new friends almost daily in the mining and metallurgy fields.

Forward stressed that the prospect of making large profits



View shows a Tri-Clover stainless steel filter and several of the valves installed at the Passaic, N.J. plant of Revlon, Inc.

TRI-CLOVER
FITTINGS and VALVES
protect product quality
for *Revlon* Inc.

REVLON—"the greatest name in cosmetics" has established an enviable reputation for highest quality products in the field of cosmetics and beauty preparations.

In the modern and efficient Revlon plant at Passaic, N.J., are numerous Tri-Clover Division stainless steel fittings, valves, and filters, all helping to protect the inherent high quality of hand creams and lotions bearing the famous Revlon label.

This is but one example of the way in which sparkling-clean Tri-Clover stainless steel fittings, valves, pumps, tubing and specialties are used in the chemical-process industries to assure the utmost protection against corrosion and product contamination.

Our experienced engineering service is at your disposal to help solve *your* specific corrosion-resistant piping problems.

See your nearest TRI-CLOVER Distributor

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Tri-Clover Division
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I-157

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Southern U. S. Gets New Adipic Acid Plant

By swinging on stream a new large-volume adipic acid plant at Luling, La., Monsanto Chemical Co. has put itself in the position of nation's largest adipic acid producer for uses other than nylon manufacture. New unit marks the first one to be integrated with raw-material facilities of former Lion Oil Co., acquired by Monsanto in 1955.

Long used in nylon manufacture, adipic acid has recently vaulted into use for making urethane foams for cushioning or construction applications. Adipic will be used in manufacture of flexible and rigid foams.

is remote unless basic economic facts of the mineral industry are understood. And, he added, you must have a mineral reserve large enough and rich enough to justify exploiting.

Hydrometallurgy differs fundamentally from the chemical industry: It's more concerned with the chemistry of operations than with physical procedures. Every plant and process is unique because it's geared to a specific starting material. Profits come from sale of an expendable source rather than from ingenuity of the process or the quality or type of product sold.

Forward concluded that hydrometallurgical methods are efficient now and will be improved even more. But they will always be limited by the perversity of solids, liquids and gases in heterogeneous systems, by thermodynamic equilibria and reaction kinetics, and by that inescapable economic and physical factor—time.

Air Valves Actuated By Electric Signals

Controlling air-operated valves over a distance of 2.5 miles presents a problem. A combination electronic-pneumatic system controlling flow in an HCl pipeline provided the answer at Stauffer Chemical Co.'s Louisville, Ky., plant.

Signals flow between the valve site and the plant control room, 2.5 miles distant, via specially strung telephone wires. Three small air compressors, at the valve site, operate the valves. Flow, temperature and pressure information is transmitted back to the control house where these variables are continuously recorded.

Problem arose when Stauffer, which had been supplying HCl to nearby Du Pont plant, through the pipeline, also contracted to supply B. F. Goodrich. The HCl line had to be split 2.5 miles from the plant to supply the two customers. A neat bit of engineering solved the resulting control problem.

Electronic system used by Stauffer was designed by Manning, Maxwell & Moore.

News Briefs

Paraxylene: Sinclair Refining Co. is readying plans for a $6-million aromatics-recovery unit at Houston, Tex., to turn out 50 million lb./yr. of paraxylene. Target on-stream date is mid-1958.

Propylene: Sinclair Chemicals will market high-purity propylene from a new unit at its Marcus Hook, Pa., refinery. New facility, to be on stream soon, will supply raw material to Hercules Powder's polypropylene plant at Parlin, N. J.

Acrylic acid: B. F. Goodrich Chemical Co. is swinging on stream at Calvert City, Ky., a new multi-million-lb./yr. unit for making glacial acrylic acid. Unit will be on stream early this year.

Liquid helium: Lockheed Missile Systems Div. is producing liquid helium on a commercial scale at its laboratory at Palo Alto, Calif. Lockheed has lined up a number of electronics firms as customers.

Petrochemicals: Esso Standard is launching a $46-million program at its Baton Rouge, La., refinery to upgrade and expand facilities for producing petrochemicals, including ethylene, propylene and industrial alcohols. One major item: a 27,000-bbl./day Powerformer, one of the largest catalytic reforming units in the oil industry.

SAFETY SWITCHES STAND UP UNDER 100,000 AMPERE SHORT CIRCUIT TEST!

INDEPENDENT TESTING LAB RELEASES FINDINGS AFTER GRUELLING "TORTURE RACK" TESTS

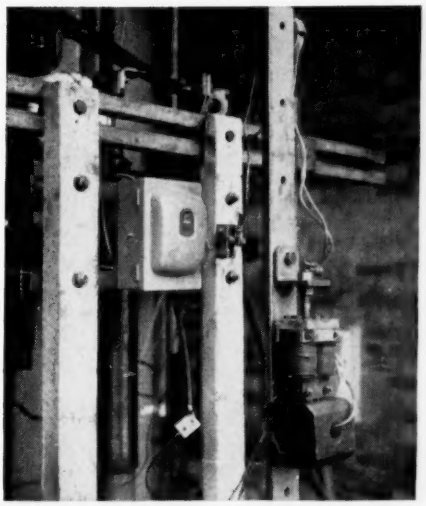
Unprecedented tests have been completed on 30 through 600 ampere rated Square D safety switches equipped with high capacity current limiting fuses. During these tests, switches were closed on a short circuit system delivering up to 100,000 amperes (symmetrical—R.M.S.). In addition, the fault was applied on the closed switches. *All switches withstood the shocks without any sign of failure!*

High Capacity Systems Demand Stamina

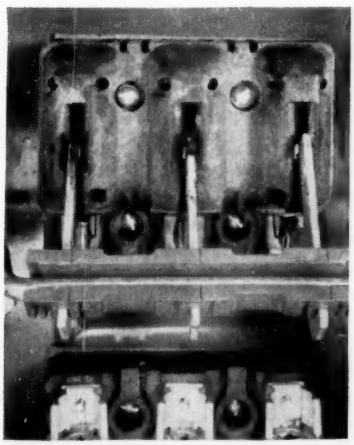
High capacity systems capable of delivering tremendous short circuits are becoming more and more prevalent with the growth of electrical loads. Network systems in metropolitan areas are a source of such faults. Another, the heavy industrial areas, with a concentration of sub-stations and rotating machinery. Terrific stresses and heat generated by such faults are serious hazards to both personnel and equipment unless properly contained. That is why proven protection for switching service and feeder circuits is of major concern.

Square D Standard Switches Do The Job

These tests offer conclusive proof that standard Square D Type HD and Type ND switches, equipped with high capacity current limiting fuses, can be used on such systems without fear of failure. You pay no premium for the proven performance they offer. Why settle for less?



Square D switch on "torture rack" during test involving up to 100,000 ampere short circuit



SUMMARY TABLE • Extract from Report No. S/NA R66—Sheet No. 5

Ampere Rating	Voltage Rating	Catalog Number	Average Symmetrical Prospective Current R.M.S.	Recovery Voltage R.M.S.	Maximum Total Arcing Time	Fuse Type
30	250	A85351	96,600	252	.0009	A2Y-30A
30	250	A85351	96,400	253	.0010	FRN-30A
30	600	A85341	107,000	590	.0020	A6Y-30A
30	600	A85341	106,000	601	.0027	FRS-30A
60	250	A86352	96,400	248	.0010	A2Y-60A
60	250	A86352	95,200	252	.0019	FRN-60A
60	600	A86342	106,000	605	.0011	A6Y-60A
60	600	A86342	108,000	598	.0020	FRS-60A
60	600	A86342	107,000	601	.0013	NAS-60A
100	250	A86353	95,200	253	.0009	A2Y-100A
100	600	A86343	108,000	604	.0014	A6Y-100A
200	250	A86354	95,200	253	.0037	A2Y-200A
200	600	A86344	107,000	602	.0011	A6Y-200A
400	250	A86355	95,900	252	.0039	A2Y-400A
400	600	A86345	106,000	611	.0050	A6Y-400A
600	250	A86356	94,500	251	.0062	A2Y-600A
600	600	A86346	107,000	601	.0062	A6Y-600A

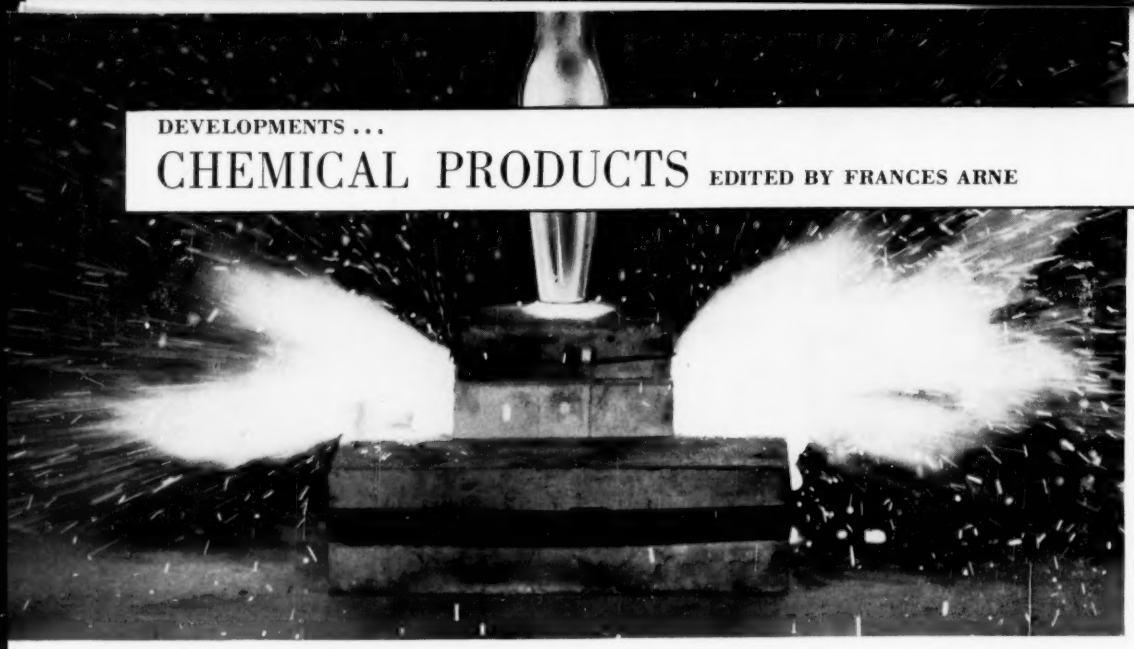
Above • Extract of Nelson High Power Laboratory Report C/NA-66

At left • No sign of failure in this switch interior after 100,000 ampere short circuit test

SQUARE D SAFETY SWITCHES GIVE YOU *Certified* PERFORMANCE!

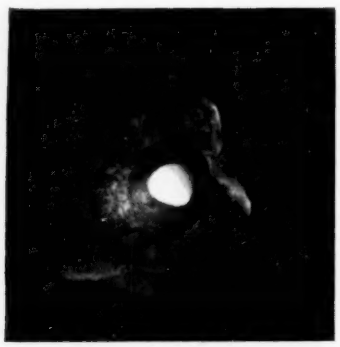
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

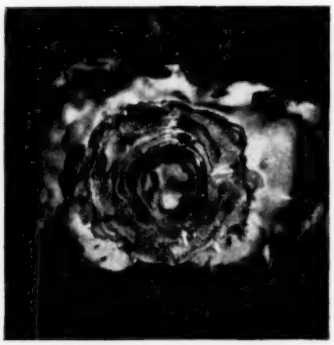


Burn-through tests on new Astrolite vs. steel exposes ½-in-thick slabs to oxy-acetylene torch at 4,500 F.

Steel burns through after only 42 sec.



Astrolite stands up better even after 142 sec.



Resin-Silica Vs. Missile-Made Heat

New silica-reinforced phenolic — in thinner, less dense sections than competing materials require — resists 10,000 F. for short one-shot uses like ICBM nose cones.

Missile engineers, faced with selecting materials for applications where temperature may range as high as 10,000 F., have a new candidate to consider.

Combination of virtually pure vitreous silica fibers and a high temperature phenolic resin binder, it is called Astrolite. In a 4,500 F. burn-through test, it outperforms a plate of steel of equivalent thickness by a factor of more than three to one. When weight is a consideration, as it usually is in missile work, a pound of Astrolite performs better than 15 lb. of steel.

It has also proved superior to asbestos-phenolic and fiber glass-phenolic combinations. Comparative thicknesses required for 100-sec. burn-through times: Astrolite—0.39 in.; fiber glass phenolic—0.63 in.; asbestos phenolic—0.47 in.

The new material is of particular interest for short-interval, one-shot applications such as liners for rocket engines and nozzles, nose cones for intercontinental ballistic missiles and heat shields to protect critical components.

Silica reinforcing medium used in Astrolite is tradenamed Refrasil, known for over 10

Newsworthy chemicals this month

—Page number is also Reader Service code number—

For more about any item, use the Reader Service Card

years as a high temperature insulation material for jet aircraft. Pre-impregnated Astrolite fabrics and also fabricated parts are available. Basic Refrasil-fabrics are available for impregnation elsewhere.

In most burn-through applications, both temperatures and gas velocities are extremely high. Material failure results from both thermal melting and mechanical erosion. The Refrasil used for Astrolite products is said to be advantageous not only because of its high melting point but because of its resistance to erosion as well. Above 3000 F. the viscosity of Refrasil is high enough to prevent it from being easily blown away. Most other refractory materials would become quite fluid at these same temperatures.

Also, the Refrasil vaporizes when it finally is removed. This vaporization tends to cool the surface of the material and contributes to a slower burn-through rate.

In tests run to date, only graphite and carbon have exceeded Astrolite in burn-through times. These two materials, while better in this one respect, were so poor in others that their applications would be severely limited. They both were extremely brittle materials which could be broken very easily. They also were such good conductors of heat that the cold side temperatures of test specimens reached 1,000 F. in a matter of few seconds. While these materials would not burn through themselves, they would not furnish any protection to critical components behind them.—**H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles, Calif.** 74A

Plastic for Pipe

New rubber-plastic promises resistance to boiling water.

At 220 F., new rubber-plastic material is about equal in strength to conventional pipe plastics when exposed to 160 F., according to laboratory tests. At 160 F., the product's strength is about twice the strength of standard pipe plastics. None of the plastics now in general use for pipe are suggested for applications where temperatures climb above 175 F.

Called Kralastic HTHT, the new plastic is a combination of acrylonitrile, butadiene and styrene. It is going into production at the Baton Rouge, La., plant of the company's Naugatuck Chemical division. It is priced in approximately the same range as plastics now in wide use for pipe.

Further development work will be needed before it is ready for the home plumbing pipe market. A more immediate use is in radiant heating pipes. Industry is also testing it for pipe used to carry hot acids, and in molded parts exposed to high heat, such as ducts and housings in auto engine compartments.—**U. S. Rubber Co., 1230 Ave. of the Americas, New York, N. Y.** 76A

For More Information . . .

about any item in this department, circle its code number on the

Reader Service

postcard inside the back cover

Silicone Intermediate

Dry transparent flake form eases resin polymerization.

A new silicone intermediate called Z-6018 can be polymerized with a variety of organic resins. Shipped in the form of dry transparent flakes, it produces easier resin polymerization by making more precise concentrations possible, and by eliminating a potential subsequent solvent removal step.

Either solvent or fusion processing may be used. No special equipment or handling is required.

Finished copolymers lend themselves to applications where the increased heat stability, weathering, and electrical properties of silicones are desirable.

Resins with which Z-6018 can be copolymerized include alkyds, polyesters, phenolics,

Yes! . . . it's ALL STEEL

HP RANGE:
½ to 50 hp

RATIOS:
4:1—14:1—24:1 (or 20:1)

OUTPUT SPEED RANGE:
420 to 5 rpm

TORQUE RATINGS:
up to 31,500 lb-in

FALK
ALL STEEL
Shaft Mounted Drive

. . . Steel can "take it"!

STEEL frame . . . of fabricated plate supports all rotating elements—provides double the ability of iron to maintain vital alignment of revolving elements, even under shock load or external impact.

STEEL housing . . . will not fracture, serves only as protective cover and lubricant reservoir. Therefore, lubricant supply is safeguarded.

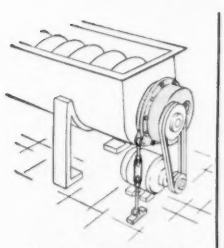
STEEL tie-rod and straddle-mounted tie rod brackets . . . are fastened to heavy steel frame by steel bolts in double shear.

DELIVERIES TO MEET YOUR REQUIREMENTS

Off-the-shelf delivery **from your Authorized Falk Distributor.** ***Shipment from factory or warehouse stocks*** **within 72 hours after receipt of your order.**

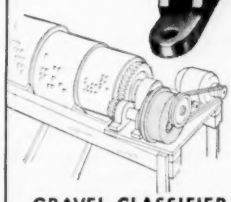
Write for Bulletin 7100

A FEW TYPICAL APPLICATIONS

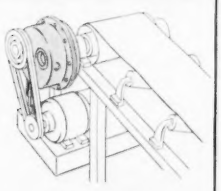


SCREW CONVEYOR

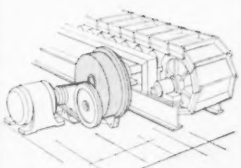
BUCKET ELEVATOR



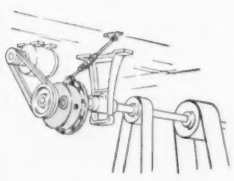
GRAVEL CLASSIFIER



BELT CONVEYOR



APRON FEEDER



LINE SHAFTING

THE FALK CORPORATION, 3001 W. CANAL ST., MILWAUKEE 1, WIS.
Representatives and Distributors in Most Principal Cities
Manufacturers of Quality Gear Drives and Flexible Shaft Couplings

FALK
. . . a good name in industry

epoxies, epoxy esters, cellulosics, polyols and partial glycerides.—**Dow Corning Corp., Midland, Mich.** 76B

Activated Carbon

Molded shapes are commercially available for the first time.

Featuring a high adsorption capacity, and much easier to handle than activated carbon granules of equal volume, a new line of cube and wafer shapes is expected to find wide usage in the adsorption of unwanted odors and vapors.

The cubical shape was designed to be placed in the cases of hermetically sealed relays and precision instruments. A single cube in a case adsorbs vapors driven off from the plastic insulation of the instrument wires by the heat generated during operation—vapors that might otherwise corrode the precious metal contact points. Cube weighs 1.2 gm., measures about $\frac{3}{8}$ in. on a side.

Wafer shape, available in various sizes, was designed to fit bottle caps.—**National Carbon Co., 1300 Lakeside Ave., Cleveland, Ohio.** 78A

Magnesium Methoxide

Useful for drying alcohols and in preparation of stable gels.

Magnesium methoxide is now readily available in commercial quantities. Anderson has developed a new process for its continuous production. It is useful for drying alcohols and to prepare stable gels.

To produce absolute dry methanol the magnesium methoxide solution is added to the wet methanol in sufficient quantity to remove the water by the following reaction:

$$Mg(OCH_3)_2 + 2H_2O \rightarrow Mg(OH)_2 + 2CH_3OH$$

Very stable and limpid gels can be produced by adding water to the alcohol solution of magnesium methoxide. These gels are useful for solidifying alcohols, oils, unstable liquids. Gels can also be impregnated with other metal oxides for use as catalysts: in the preparation of magnesium salts of organic acids; for catalytic condensation of carbonyl compounds; to produce dielectric coatings on steel.—**Anderson Chemical Co., Weston, Mich.** 78B

Briefs

Methallyl acetate (isobutenyl acetate) is now readily available in 97% minimum purity grade. It is used primarily as a monomer in polymerization reactions, it is also expected to be of interest in preparing methallyl derivatives of value in specialty rubbers, safety glass liners, molding powders, castings and laminates.—**FMC Organic Chemicals Div., 161 East 42nd St., New York, N. Y.** 78C

New brominated compounds used to impart flame-proofing and self-extinguishing characteristics to plastics, protective coatings, fluids, textiles, paper and wood products are now available. They are tetrabromobisphenol-A, tetra-bromophthalic anhydride, tris (2-bromoethyl) phosphate, pentabromophenol, and tris (2, 3-dibromopropyl) phosphate.—**Michigan Chemical Corp., St. Louis, Mich.** 78D

Sodium hydride in production quantities is now available. This highly reactive solid is produced in mineral oil dispersions, making it possible to handle it safely in air.—**Callery Chemical Co., Pittsburgh, Pa.** 78E

Economic synthesis of geraniol is the first announced result of a company research program initiated twelve years ago to provide a range of terpene alcohols and related aromatics of extreme purity, at stable prices and in plentiful supply. New commercially available synthetic is expected to be used as a direct replacement of high quality geraniol produced from citronella oil.—**Glidden Co., Cleveland, Ohio.** 78F

Silk-bright rubber films with excellent chemical and mechanical resistance can be produced on metals via a new two-component lacquer containing synthetic rubber. The rubber is vulcanized by the air.—**Goldschmidt AG, Mannheim-Rheinau, Germany.** 78G

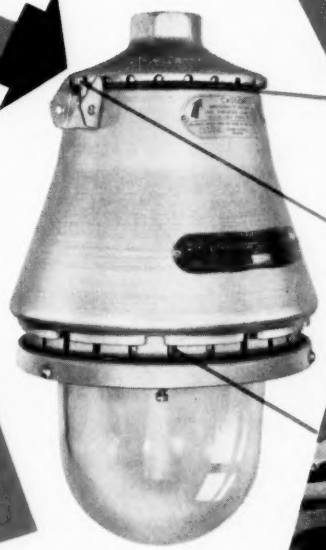
Three base detergent acids, identified as Tenn-Acids 820, 873 and 864, now offers a simple and practical method for the preparation of concentrated, low cloud point, liquid detergents, based upon alkyl aryl sulfonates for the textile and allied industries.—**Tennessee Corp., 1330 West Peachtree, Atlanta, Ga.** 78H

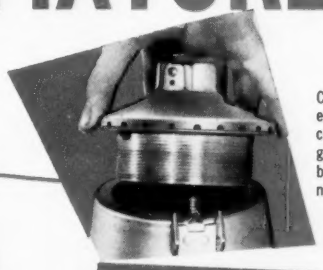
Anthracene is being made domestically on a substantial commercial scale for the first time in 40 yr. A new installation produces a 90-95% pure crystalline anthracene from creosote oils. Production in pure form of related high-boiling chemicals from creosote oil is expected to follow. —**Barrett Div., 40 Rector St., New York, N. Y.** 78I

Molders of reinforced plastics are being offered a new line of fine strand roving and mat known as Fiberglas Super-Fi. It is said to provide more rapid and complete resin wet-out and improved bonding, improved surface finish with more uniform strength throughout the molded piece. — **Owens-Corning Fiberglas Corp., 598 Madison Ave., New York, N. Y.** 78J

APPLETON "AA-51" SERIES VENTED EXPLOSION-PROOF LIGHTING FIXTURES

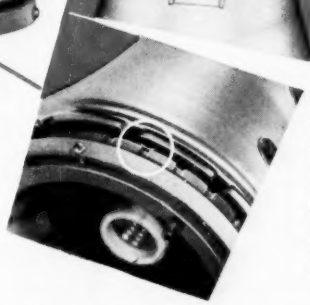
Exclusive NEW Anti-Vibration Guard!





Close-up showing canopy, extra-safe multiple "AA-51" contact threads, and anti-vibration guard with V-shaped metal prong before engaging canopy notches.

Canopy is securely locked against vibration disturbance by positive engagement of V-shaped metal prong in tightly sealed canopy notch. This anti-vibration guard may be quickly released by hand pressure for maintenance.



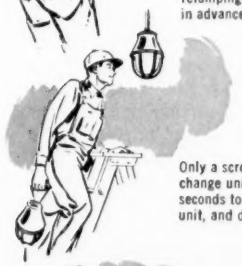
Similar in action to canopy guard, this close-up shows anti-vibration guard locking globe ring to dome unit assembly. Metal prong in dome unit is securely engaged by notched globe ring to prevent accidental loosening. This anti-vibration guard also may be quickly released by hand pressure for maintenance.

Interchangeable Unilet

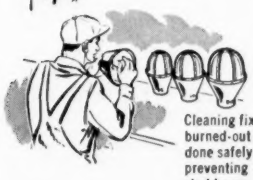
Identical diameters "A" on Dome Assemblies permit quick interchange of fixtures with different wattages (from 60 Watt to 500 Watt).

58 Second Relamping

Series "AA-51" stand-by units are ready at an instant's notice for relamping... with handles attached in advance.



Only a screwdriver is needed to change units . . . and only 58 seconds to climb ladder, change unit, and descend.

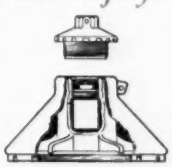


Cleaning fixtures, changing burned-out lamps, can be done safely at bench . . . preventing costly shutdowns.

The fixture with "all" the features now sets even greater standards of efficiency and safety!

APPLETON'S new anti-vibration guard on all "AA-51" vented explosion-proof fixtures assures users of positive protection against spark caused mishaps due to vibration conditions. Coupled with multi-thread safety design where a "flame-tight" contact chamber permits servicing *even with the current on*, this new anti-vibration guard demonstrates APPLETON'S continuing quality research program to bring you the finest in electrical products. Check these other features for proof of "AA-51" design leadership and adaptability for your requirements. Write for complete information today.

Sold through franchised wholesalers only



"Full Circle Venting"
Porous metal interior and specially designed hood dissipate heat evenly and safely . . . keep fixture temperature down, provide longer lamp life.

APPLETON ELECTRIC COMPANY
1742 Wellington Avenue, Chicago 13, Illinois

APPLETON ELECTRIC PRODUCTS

Also manufacturers of:

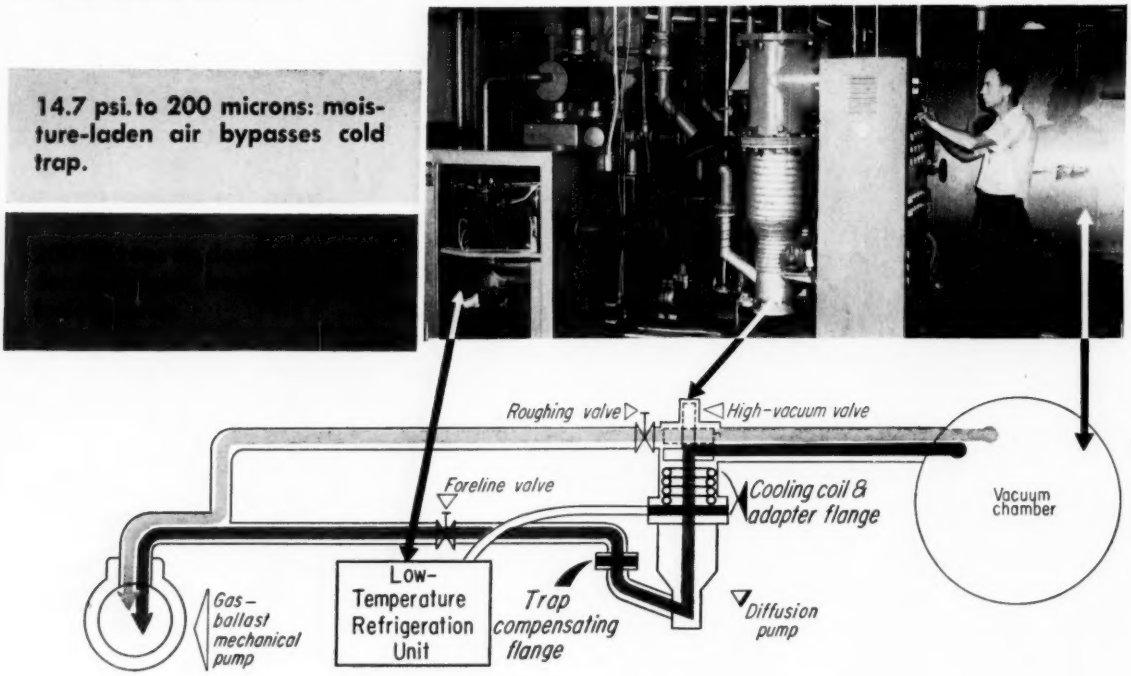
Industrial Lighting Equipment

Automatic Reelites

"ST" Series Connectors

Malleable Iron Unilets

14.7 psi. to 200 microns: moisture-laden air bypasses cold trap.



Cold Trap Cuts Vacuum Cycle Time

Unique design and location of trap cuts exhaust time and refrigeration costs to one-third of present values.

Does your plant utilize any high-vacuum batch processes? If so, perhaps you should consider a real time-saver developed recently, the novel cold trap sketched above.

Introduced by National Research Corp., this trap drastically reduces evacuation time for processing systems operating on short batch cycles in the micron pressure range.

▶ **Moisture Loads Pump**—High-vacuum batch systems always have been plagued by entry of moisture during the shutdown or loading part of the cycle. Not only does moisture enter with the air, but it also adheres to parts or material placed in the vacuum chamber.

Later, in the exhaustion part of the cycle, vaporization of this water and expansion of the vapor results in pump loads far greater than those encountered within a moisture-free system, especially in the micron pressure range.

Time required to reach the desired working vacuum (usually less than 1 micron) may vary by a factor of three to five, depending upon the amount of water admitted.

▶ **Exclude or Remove?**—There are two approaches to solving the moisture problem. Either you can prevent entry of water through dehumidification, or you can speed its removal from the system.

Dehumidification and air conditioning have met with little success. Cold traps designed to remove condensables during pump-down of the system have performed better. But, their inability to meet economic requirements has discouraged industry from using them widely.

To be acceptable, a cold trap usually must operate under —110 F., since at this temperature the vapor pressure of water falls below 1 micron.

Another qualification is that trap should be sealed from contact with chamber atmosphere during loading to avoid excessive frosting. Of course, defrosting should be possible without extensive downtime. And, finally, trap must be inexpensive to operate.

▶ **Delayed Action**—NRC claims that its cold trap satisfies all of these requirements. Location of the trap is unique in that it comes into use only after

Equipment Developments This Month

Page number is also Reader Service code number

For more details, use Reader Service Card

the chamber pressure has been reduced to 200 microns by the mechanical pump. Too, it is isolated from the chamber during loading.

This delay in the trap's use eliminates rapid icing which would normally occur during pumping operations above 200 microns. Defrosting frequency is reduced and the decreased vapor load can be handled by a small, low-power refrigeration unit.

To de-ice, the refrigerator is shut down. Coil then defrosts rapidly, discharging accumulated moisture into the gas-ballast pump which vents it to the atmosphere.

▶ **Construction Details**—The cold trap, consisting of a cooling coil incorporated in an adapter flange, is installed between the diffusion pump and the high-vacuum valve.

A packaged low-temperature refrigerator, capable of developing temperatures down to —150 F. in less than 6 min. after start-up, supplies coolant to the coil. This insures a cold-trap surface temperature of at least —110 F.

Size of the refrigerator package is determined by the individual operation. Normally, a 4-hp. unit will meet cold-trap coolant requirements for two 16-in.-dia. diffusion pumps.

System is completely automatic. No manual operation is required to balance it under varying temperature and load conditions. A compensation flange at the foreline connection eliminates need for piping changes when installing trap.

▶ **How It Works**—During the roughing portion of the exhaust cycle, the high-vacuum valve is closed, isolating the trap from chamber while the high-pressure air is removed. When chamber pressure reaches 200 microns, the high-vacuum valve opens, bringing the cold trap and diffusion pump onstream. Coil of the cold trap condenses moisture out of the air stream before it reaches the diffusion pump.

▶ **Proof Positive**—Kent Plastic Corp. reports that prototype installation of the NRC cold trap has made its vacuum-metallizing operations independent of plant humidity. A single refrigeration unit operates for less than $500/yr. Liquid nitrogen cost used to run $1,500-2,500/yr. for the same service. Furthermore, pump down time is less, rejects are fewer and operating costs are lower.—**National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.** 80A

Equipment Cost Index

Industry	June 1957	Sept. 1957
Avg. of all	224.1	225.0
Process Industries		
Cement mfg	215.3	216.6
Chemical	225.5	226.6
Clay products	209.2	210.4
Glass mfg	213.0	214.0
Paint mfg	216.6	217.4
Paper mfg	217.3	218.3
Petroleum ind	221.1	222.0
Rubber ind	223.9	224.8
Process ind. avg	222.8	223.7
Related Industries		
Elec. power equip	228.4	229.8
Mining, milling	226.9	228.0
Refrigerating	253.0	254.0
Steam power	212.0	212.8

Compiled quarterly by Marshall and Stevens Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; March 1957, pp. 266–7 for annual averages since 1913.

Aluminum Gate Valves

Offered in sizes from ½ through 24 in.

Gate valves of aluminum alloy are now offered for general application after 2½ yr. of development and testing by Darling Valve & Mfg. Co. Covering a size range from ½ through 24 in., line includes types for every requirement where aluminum piping systems now are used or planned.

Valves incorporate the principle of a fully revolving double-disk parallel seat. They are expected to make possible sizeable savings, particularly in the larger sizes where differences in basic weight are more pronounced.—**Darling Valve & Mfg. Co., Williamsport, Pa.** 82A

Compressor Conversion

Adds turbocharging to boost horsepower.

Completely integrated engine auxiliaries are now offered at low cost to increase substantially the horsepower ratings of many existing two-cycle engine-

driven compressors. Field reports on pipeline and refinery compressors already converted indicate that these units are gaining fuel economies as well.

Depending upon the size and type of engine, conversion takes from 4 to 7 days, involves relatively simple assembly.

One type of conversion kit, the parallel system, is an all-exhaust-driven turbocharger auxiliary that complements the existing engine's reciprocating scavenging pumps. The other, or series type, is an all-exhaust-driven turbocharger introduced into the engine air-intake system as a first stage of compression. Combined with an engine-driven blower for second-stage compression, it assures supercharging from startup as well as throughout all speeds and loads.—**Cooper-Bessemer Corp., Mt. Vernon, Ohio.** **82B**

Internal-Fin Tube

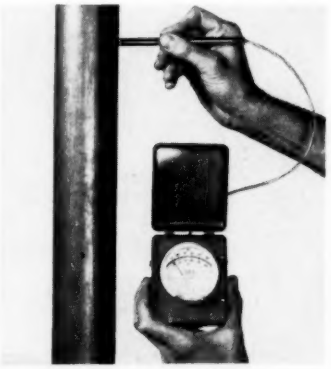
Now available in impervious graphite material.

Advantages inherent in the new internal low-fin Karbate impervious graphite tube make it possible to obtain the corrosion resistance of Karbate tubes at the cost of carbon steel.

Largely, it's due to improved heat transfer over smoothbore Karbate tubing, coupled with the nonfouling, non-corroding character of the Karbate material. Less heat transfer area is needed which reduces size of shell, baffles and tube sheet.

Design of the low-fin tube augments the differences between streamline and turbulent flow. For fluids in streamline flow, heat transfers primarily by conduction. As fluid velocity rises, helical pitch of the fins, causes turbulent flow at right angles to the long axis of the fins. This action keeps fluid turbulent between the fins.

Karbate low-fin tube now in production is 1¼ O. D. with 2.6 times as much internal surface as a smooth-bore 1¼ O. D. Karbate tube.—**National Carbon Co., P. O. Box 6087, Cleveland 1, Ohio.** **84A**



Surface Thermometer

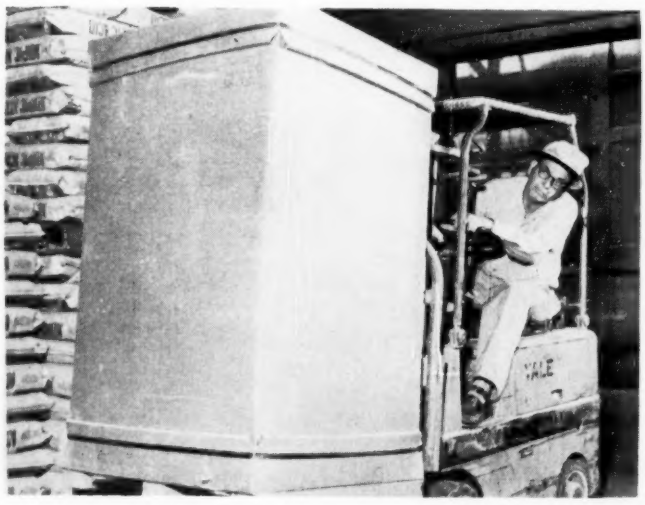
Spring-loaded sensing element boosts instrument's reproducibility.

You no longer need a steady hand to measure surface temperatures accurately. The Pyrocouple, a new surface-temperature detector developed by Royco Instruments, features a sensing probe that eliminates pressure-sensitivity.

Recommended primarily for use on reasonably clean surfaces, the special probe's sensing element is spring-loaded between two projecting lips. This arrangement insures that element is applied with constant pressure from one reading to the next.

Pyro-couple is available in two basic styles—remote-probe type (illustrated) which utilizes a 30-in. cable, and integral-probe type, which has the sensor mounted on rear surface of the indicator.

Scales, which are calibrated in both Fahrenheit and Centigrade, are available in four ranges, covering the span from 0 to 1,000 F. Accuracy of 5% on all ranges is standard.—**Royco Instruments, 722 Arthur St., Albany 10, Calif.** **84C**



One-Way Container Cuts Adipic Acid Handling Cost

This new 1-ton corrugated fiberboard container cuts both time and cost of unloading and handling bulk quantities of adipic acid. Rectangular body encases special water-resistant fiberboard tube which holds the acid. Corrugated covers remove easily for quick emptying; entire unit rests on built-in pallet. Developed by Du Pont Co., Pillar-Pac container will be generally available soon through licensed manufacturers.—E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del. **84B**

Take the tedium out of correlation studies with this powerful electronic computer

ROYAL PRECISION LGP-30

Large capacity . . . easily programmed and operated . . . mobile . . . low in cost

Compact, simple to use . . . Royal Precision LGP-30 brings high-speed electronic computation *right to your desk* . . . relieves you of the tedium of statistical analysis in such areas as research and product development, quality control and process control. And at the lowest cost ever for a complete computer system!

Faster answers; unusual capacity. Used wherever *you* want it, LGP-30 operates from any conventional wall outlet, is self-cooled. Providing fast, effortless answers for all types of statistical studies—correlations, analysis of variance, regression analysis, curve-fitting – LGP-30 gives you speed and memory (4096 words) comparable to computers many times its size and cost . . . stored-program operation for complete flexibility. Result: you save valuable time . . . handle more assignments . . . go forward to truly *creative* work.

Easy to operate and program. Controls have been so thoroughly simplified, LGP-30 may be operated with only minimum computer experience. Answers are printed out directly . . . do not require deciphering. Programming is easily learned. A library of sub-routines, plus programs for a wide variety of applications (including Box technique for experimental design), are available.

Wide range; exceptional value. The most powerful computer of its size yet developed, LGP-30 is the greatest value in today's market. Remarkably small initial investment is combined with low operating and maintenance costs. Service facilities are available coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Equipment Division, Port Chester, N. Y.

ROYAL McBEE

WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS AND MAKER OF DATA PROCESSING EQUIPMENT

Hard Surfacing

Pieces of cemented tungsten carbide on fiber backing for easy use.

Kenplate cemented tungsten carbide material, adapted from Kennametal, is a new form of hard-facing material for protecting metal surfaces against abrasion and wear.

Consisting of small hexagonal plates of cemented tungsten carbide assembled in continuous pattern on an adhesive glass fiber backing, Kenplate can be cut or joined to form practically any required size or shape.

Adhesive backing holds the small plates in position while they are being bonded to the base material with epoxy adhesives, silver solder, or conventional brazing materials. Normal joint spaces are less than 0.002-0.003 in. Plates are either 0.425 or 0.210 in. across flats. Smaller ones come in 0.04, 1/16 and ⅛ in. thickness; larger ones in 1/16, ⅛ and ¼ in.—**Kennametal, Inc., Latrobe, Pa.** 86A

Pneumatic Transmitter

Force-balance device for pressure and level.

Pneumatic model P pressure and liquid-level transmitter is a low-cost, rugged instrument that measures pressures up to 250 psi. or ranges as low as 0-100 in. of water. Operating on the simple force-balance principle, the model P instrument transmits a linear 3-15 psi. signal to a recorder, indicating gage or manometer.

Transmitter is suitable for many different services, particularly those involving viscous fluids or materials which solidify in the static lines of pressure elements of conventional pressure transmitters. It can be mounted either horizontally or vertically on both open and closed tanks.

Only the corrosion-resistant Inconel X diaphragm assembly is wetted by the measured material. Design of unit eliminates the possibility of material backing into the air lines if the pressure diaphragm should rupture.—**Conoflow Corp., 2100 Arch St., Phildelphia 3, Pa.** 86B

Continuous Pulper

Improves yield and uniformity of wood pulp.

Major advantages claimed by Sprout Waldron's new continuous chip digester are short cooking, lower chemical cost, improved yield, uniformity, operating flexibility and economy.

Essentially a horizontal pressure vessel, digester is really two independent operating units in one. Each side of the digester is divided into an upper and lower section.

Entering through a rotary pressure lock, presteamed chips are conveyed along a perforated metal trough in the digester. Constant strength cooking liquor sprays onto the chips. At the end of the trough, the chips drop to another conveyor just below and return the full length of the digester. Liquor dropping from the top trough wets the returning chips.

Cooking time in the digester is 10-15 min. for semi-chemical and 30-45 min. for kraft or bleach-type chemical pulp.

First unit is now going into production on 9-pt. corrugating board at Sonoco Products Co., Hartsville, South Carolina. A second system operating on kraft will start at the Southern Advance bag plant, Robert Gair Div., Continental Can, Hodge, La., early next year.—**Sprout, Waldron & Co., Inc., 130 Logan St., Muncy, Pa.** 86C

For More Information . . .

about any item in this department, circle its code number on the

Reader Service

postcard inside the back cover

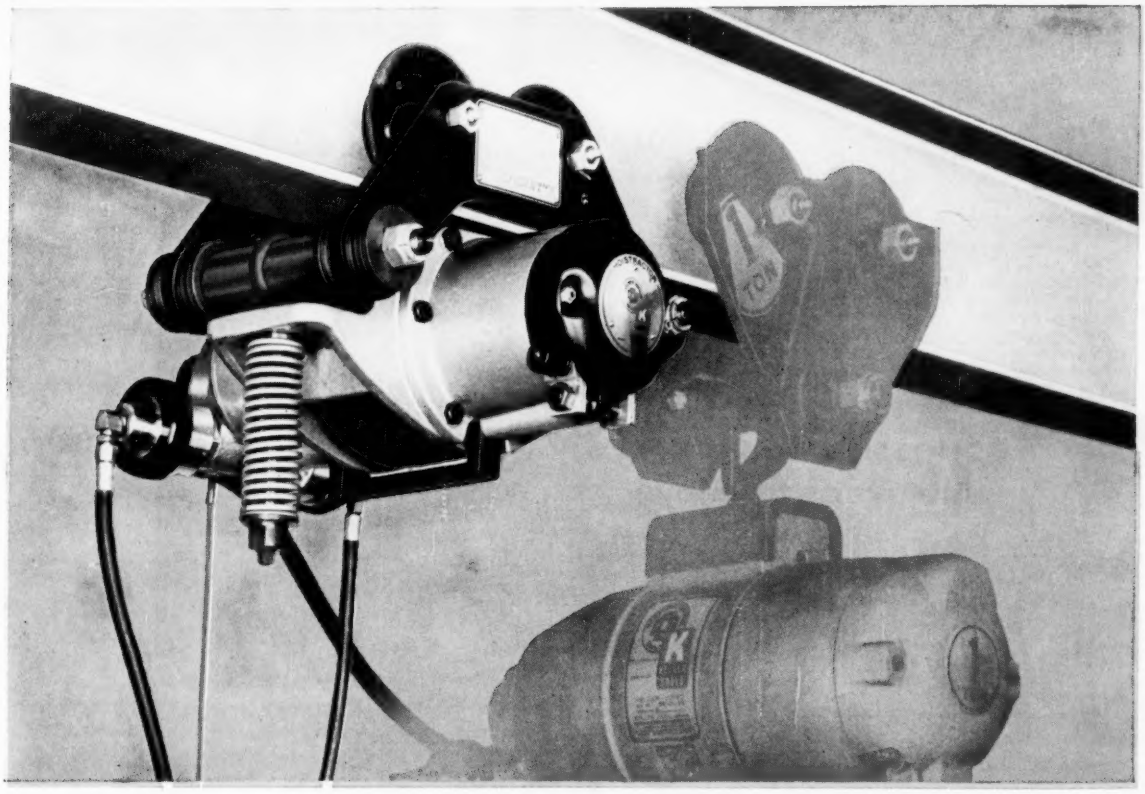
Valve Operator

Converts manual valves to proportional controllers.

Simply remove the handwheel, mount Jordan's explosion-proof Valvetrol on the stem, make a few electrical connections, and you can operate that hard-to-reach hand valve at the touch of a control-room button. Or, if you desire proportional flow control, install Valvetrol on an existing valve and connect to a suitable signal source to bypass costly shutdown and replacement.

Valvetrol (shown here on a Kates metering valve), specified more fully as a SM-11-X Valve Operator, will provide proportional control for valves requiring from 1/6 to 40 turns and stem torques up to 800 in.-lb. Operating times vary from 2 to 60 sec.

Built-in positioners, actuated by either a.c. or d.c. signals, limit instrument inaccuracy to 1/5 of 1%. Special models are available having positioning accuracies of 1/25 of 1%.—**The Jordan Co., Inc., 3235 West Hampton Ave., Milwaukee 9, Wis.** 86D



New HOISTRACTOR adds push-pull power to any beam hoist

Now, it's an easy one-man, one-hand operation to raise, lower and move loads up to two tons. Simply use Gardner-Denver's new Keller "Hoistractor." This air-powered hoist trolley—connected to any beam hoist by a drawbar—rides the same beam as the hoist. Hoist lifts and lowers . . . "Hoistractor" moves hoist and load along the beam.

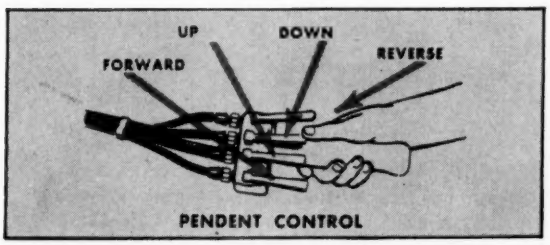
This new tractor unit simplifies moving heavy loads to truck, stock bin, machine tool or dip tank. Now, one man handles jobs such as these with greater speed and safety—without fatigue.

Powered by an axial-piston type air motor, the powerful, lightweight "Hoistractor" exerts 250-lb. drawbar pull on a beam. Speed is variable from slow creep to full-load speed of 70 ft. per min., with a no-load speed of 150 ft. per min.

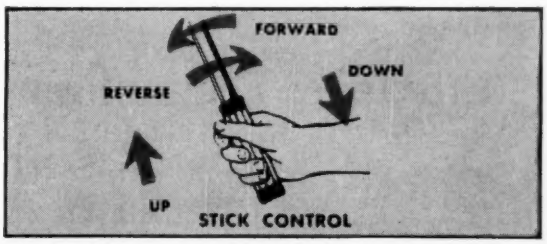
Sensitive air controls permit smooth acceleration and deceleration . . . accurate load spotting. Powerful enclosed mechanical brake, easily adjusted, provides positive, safe stopping.

Get all the facts on the new Keller "Hoistractor." Request Bulletin 87-1.

ONE-HAND CONTROL—TWO TYPES AVAILABLE



Squeeze hand grip has up-down operating levers for hoist and fore-aft levers for "Hoistractor."



Swiveled rod with four-way grip control. Raising or lowering the grip raises or lowers hoist load.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

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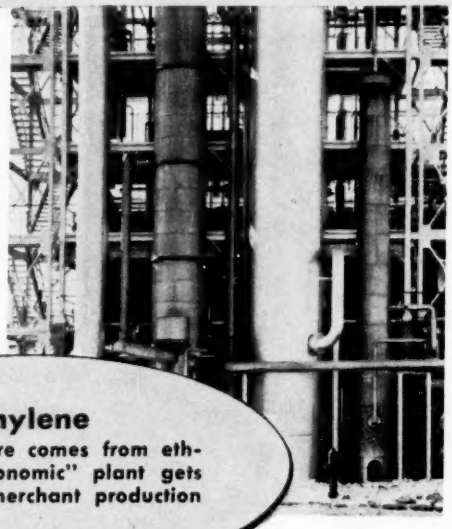
DEVELOPMENTS . . .

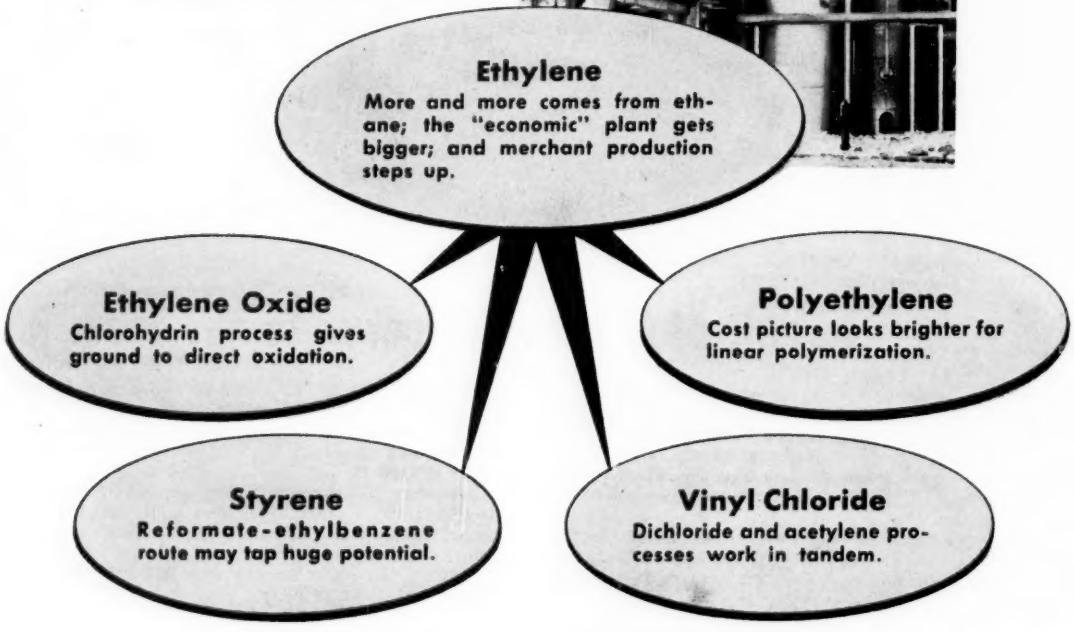
CHEMICAL ECONOMICS

EDITED BY D. R. CANNON

● *Did you see Part I of CE's Petrochemical Series in December? Coming: Part III.*

Ethylene's Restless Technology: Always on the Move





Ethylene: Technology Paints the Market Picture

James W. Bradley, Robert L. James and Richard F. Messing, Arthur D. Little, Inc.*

In this bustling segment of the petrochemical industry, a peek behind market statistics underscores one solid fact: Technology — aggressive research and process development —is determining the market picture, good or bad, for ethylene and most of its derivatives.

* For authors' biographies, see *Chem. Eng.*, Dec. 1957, pp. 206-214.

Since ethylene consumption continues to outstrip that of all other petrochemical aliphatic raw materials, it's worthwhile to see just how technology plays its key part. Total ethylene consumption in 1956, based on requirements of its derivatives, was 3.4 billion lb.—up nearly 75% from the 2 billion lb. in 1954.

► **More From Ethane**—Ethylene is being made increasingly from ethane rather than from propane or ethane-propane mixtures. Most important reason for this is that ethane gives better yields. Too, an ethane cracker can be kept on stream longer than a propane cracker, because carbon deposits on catalysts are less troublesome.

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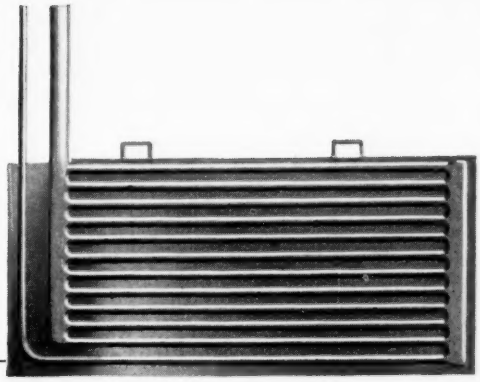

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PLATECOIL Units are available in Cold Rolled Steel, Stainless Steel, Carpenter 20, Monel, and other corrosion-resistant alloys. In addition to the many sizes and styles available as standard PLATECOIL units, special units can be built on order to fit your specific requirements.

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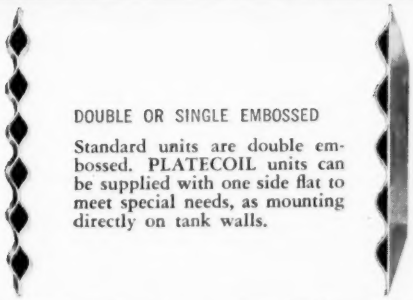

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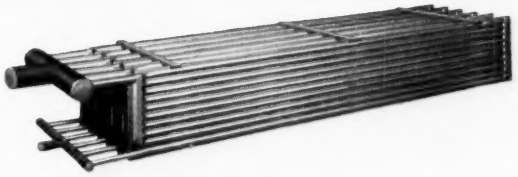

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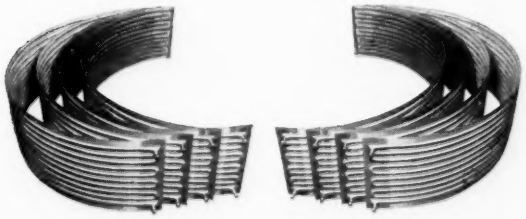
Factory-fabricated banks of PLATECOIL are available for specific applications in heating or cooling.



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PLATECOIL Units may be rolled to a specified diameter in the direction of width or length, in either single embossed or standard units.

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PLATECOIL can be galvanized, metallized, electropolished, polished for food service; prepared for plate finishes, lead and thermo-plastic coatings.

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PLATECOIL can be incorporated into heated or cooled conveyors, tank walls, baffles or partitions.

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Pipe connections can be supplied longer or shorter than standard, at right angles, in couplings, pipe nipples or elbows; in various positions.

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Tranter Manufacturing Inc.

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PLATECOIL® DIVISION

ETHYLENE: Consumption rockets 70% in two years as processors take bigger gulps of refinery gases.

Ethylene Production (1957): 3.7 Billion Pounds (Est.)

Sources (1956)	%	End Uses (1956)	%
Oil and oil-gas cracking	9	Ethylene oxide	30.9
Refinery gas	53	Ethanol (syn.)	25.0
Propane	15	Polyethylene	16.7
Ethane	23	Styrene monomer	10.8
		Ethyl chloride	9.3
		Ethylene dichloride	4.1
		Ethylene dibromide	1.1
		Misc.	2.1

Capacity—most startling ethylene statistic of all—heads for five billion lb./yr.

Producer	Location	Capacity (Million Lb.)
Allied Chemical & Dye	Tonawanda, N. Y.	30
Dow Chemical	Midland, Mich.	100
	Freeport, Tex.	325
Du Pont	Orange, Tex.	45
Esso Standard Oil	Baton Rouge, La.	370(200[1])
	Bayway, N. J.	185
Gulf Oil	Port Arthur, Tex.	800(400[1])
Humble Oil & Refining	Baytown, Tex.	80[1]
Jefferson Chemical	Port Arthur, Tex.	300(200[1])
Koppers	Kobuta, Pa.	30
Olin Mathieson Chemical	Brandenburg, Ky.	100
Monsanto Chemical	Texas City, Tex.	150
National Petrochemicals	Tuscola, Ill.	280
Petroleum Chemicals	Lake Charles, La.	200[1]
Phillips Chemical	Sweeney, Tex.	145
Shell Chemical	Houston, Tex. / Emeryville, Calif.	245
Texas Eastman	Longview, Tex.	80
Union Carbide	S. Charleston, W. Va.	520(165[2])
	Institute, W. Va. / Whiting, Ind.	165
	Texas City, Tex.	570
	Seadrift, Tex. / Torrance, Calif.	95
	Ponce, Puerto Rico	110[1]
Wyandotte Chemicals	Wyandotte, Mich.	40
Total		4,965

[1] Under construction; [2] Planned.

Another reason is that aliphatic C_3's are being diverted to LPG and polymer gasoline. Furthermore, polypropylene is now putting in its bid as an important new polymer (see p. 72) and, in the long run, may be a big propylene market.

▶ **Basic Advantage**—Primary reasons for ethylene's rapid growth are its ready availability and low price coupled with the basic position of such derivatives as ethyl alcohol, ethylene oxide.

Nevertheless, ethylene encounters some competition from acetylene for such products as acetic acid, acetic anhydride, vinyl chloride and acrylonitrile. In fact, some companies are considering making acetylene with ethylene to take advantage of the dual acetylene-and-ethylene-dichloride route to vinyl chloride monomer.

But for most C_2 derivatives that can be made from ethylene or acetylene, ethylene is preferred since its price is one-half to one-third that of acetylene.

▶ **Plant Size Is Up**—Capacity needed for economical operation has increased appreciably. In 1950, potential ethylene producers could make enough profit from a 50-million-lb./yr. plant. By 1954, 100 million lb./yr. was regarded as minimum. Now 200 million lb./yr. is generally needed.

This increased minimum has been brought about by competition from very large new plants, such as Gulf Oil's, and by increases in manufacturing costs.

▶ **Merchant Sales Boom**—Competition for merchant sales of ethylene has become keen and is partly responsible for the present 15% overcapacity in the industry. Because of this overcapacity, supply will exceed demand until 1962. In 1956, about 12% of the ethylene was supplied by merchant sales. By 1961, at least 30% should come from this source.

This trend to merchant sales is sparked by economic and technological reasons. The two most important are probably these: First, ethylene customers can get a higher return from derivatives production than from ethylene production. Second, many chemical companies using ethylene are not as familiar with dehydrogenation operations as with such synthesis operations as chlorination, nitration and polymerization.

Other reasons include increasingly wider distribution of technical process knowledge, wider availability of raw materials and manufacture of olefins by natural-gas-pipeline companies.

▶ **Natural Gas Weakens**—Ethylene made from the ethane or propane in conventionally stripped, lean natural gas is under economic pressure.

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stainless steel valves

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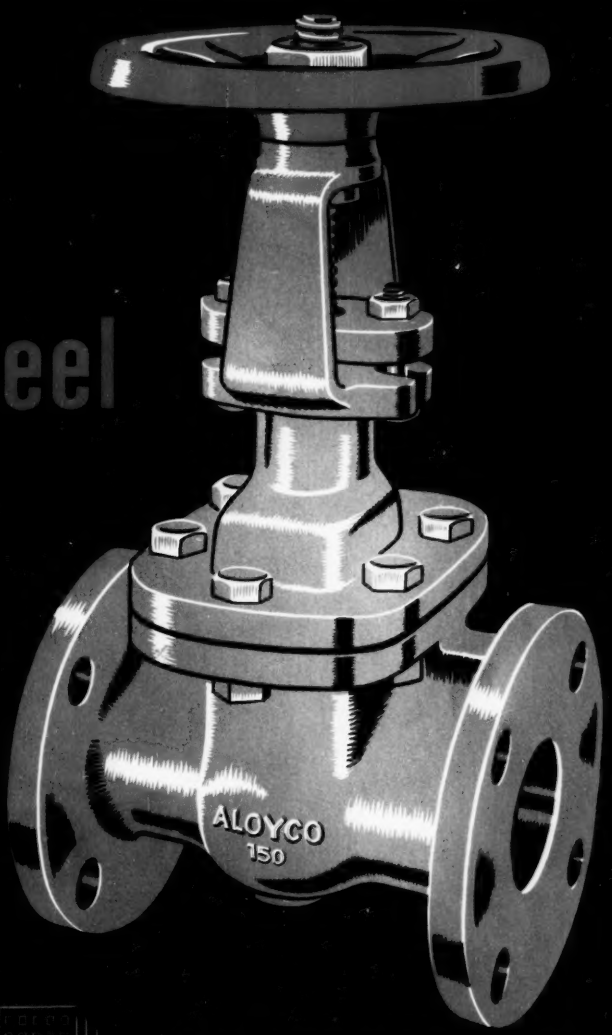

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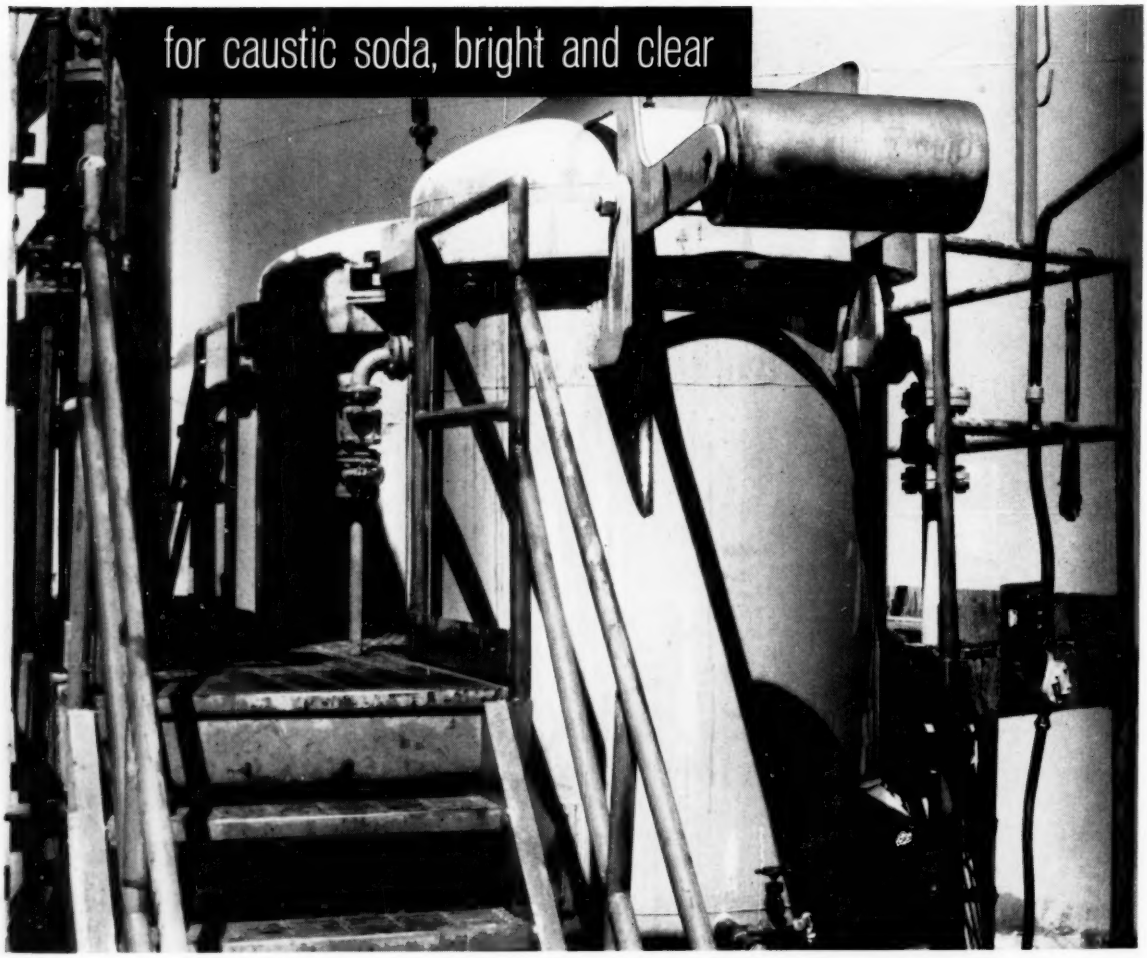

Stauffer picks Process Filters

To remove the final trace of turbidity from caustic soda, Stauffer Chemical Company installed two Process Vertical Pressure Leaf Filters at its Henderson, Nevada plant. Net result: "A bright, clear product for customers."

Says Stauffer: "PF Filters were selected after a survey of various pressure leaf filters and a series of pilot tests on this one. The equipment has been completely satisfactory as has been Process Filters' service."

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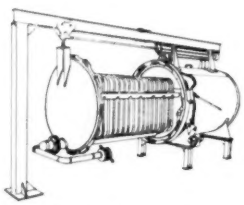
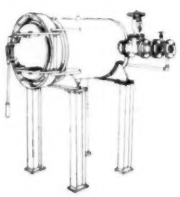


HORIZONTAL LEAF FILTERS
Bulletin H



HORIZONTAL BATCH FILTERS
Bulletin HB

CARTRIDGE FILTERS
Bulletin C

pf

Under some purchasing arrangements, pipeline companies have little control over gas composition as long as it meets minimum heat-content specifications. To assure long-term availability of natural-gas-based ethane and propane, pipeline companies may, through purchase agreements, have to exercise more control over the amount of ethane and higher hydrocarbons in the gas. This will become more important when existing pipeline-ethane-based plants are to be expanded.

▶ **Ethylene Oxide, Glycol**—Process obsolescence and continued market growth have characterized the ethylene oxide and glycol industry for the past two years.

The trend toward replacement of chlorohydrin facilities with direct-oxidation plants has, except under unique conditions, confirmed the preferred profit status of this latter route to the oxide.

Some conversion of the older chlorohydrin facilities to make propylene oxide and glycol is anticipated, particularly as markets for propylene derivatives grow. One such growth possibility is manufacture of polyethers for polyurethanes.

▶ **Glycol Keys Market**—Controlling market factor is the continued emphasis on converting ethylene oxide to ethylene glycol, and the growing use of glycol in antifreeze. About 86.3% of the ethylene glycol in 1956 came from the oxide; the rest, from formaldehyde and carbon monoxide.

Nonvolatile glycol antifreeze, more expensive than the volatile, has captured a larger share of the market — 76.9% — than was foreseen by many industry representatives. But this market is probably approaching saturation. Further growth may be slower and more dependent on other uses for both glycol and oxide.

Ethylene oxide enjoys a secure position in manufacture of other derivatives, except for acrylonitrile. Here, acetylene threatens to displace the oxide as hydrocarbon raw material. New polymers of ethylene oxide may develop an interesting spe-

ETHYLENE OXIDE: Direct oxidation of ethylene closes fast on chlorohydrin route as primary source.

Ethylene Oxide Production (1957): 1.18 Billion Pounds (Est.)

Sources (1956	%	End Uses (1956)	%
Oxidation	48	Ethylene Glycol	65.9
Chlorohydrin	52	Ethanolamines	7.5
		Nonionit detergents	7.5
		Acrylonirile	4.7
		Di- & triethylene glycols	9.0
		Glycol ethers, polyethylene glycols	4.8
		Other	0.6

New oxide capacity shows trend to oxidation.

Producer	Location	Capacity (Million Lb.)
Chlorohydrin Process		
Dow Chemical	Midland, Mich.	20
	Freeport, Tex.	220
	Plaquemine, La.	60[1]
Jefferson Chemical	Port Neches, Tex.	110
Olin Mathieson Chemical	Brandenburg, Ky.	100
Union Carbide	S. Charleston, W. Va. / Institute, W. Va.	90
Wyandotte Chemicals	Wyandotte, Mich.	30[2]
		630
Direct Oxidation Process		
Allied Chemical & Dye	Orange, Tex.	35
Calcasieu Chemical	Lake Charles, La.	57[1]
General Aniline & Film	Linden, N. J.	60[1]
Jefferson Chemical	Port Neches, Tex.	60[1]
Union Carbide	S. Charleston, W. Va.	100
	Institute, W. Va.	150
	Texas City, Tex. / Seadrift, Tex.	355
	Torrance, Calif.	50
	Whiting, Ind.	70
	Ponce, Puerto Rico	100[1]
Wyandotte Chemicals	Geismar, La.	60[1]
		1,097
Total		1,727

[1] Under construction; [2] Believed converted to propylene oxide; [3] Planned.

ETHYL ALCOHOL: Other products challenge its premier position as solvent and raw material.

Ethyl Alcohol Production (Fiscal 1957): 224 Million Gallons (95%)

Sources (1956)	%	End Uses (1956)	%
Synthetic	69.1	Aldehydes	44.5
Fermentation	28.8	Other chemical uses	24.7
Redistillation	2.1	Solvents	24.1
		Misc.	6.7

Ethanol capacity inches higher.

Producer	Location	Capacity (Million Gal.)
Synthetic		
Esso Standard Oil	Baton Rouge, La.	42
National Petrochemicals	Tuscola, Ill.	40
Shell Chemical	Houston, Tex.	20
Texas Eastman	Longview, Tex.	12
Union Carbide	S. Charleston, W. Va.	40
	Institute, W. Va.	10
	Texas City, Tex.	55
	Whiting, Ind.	15
		234
Fermentation		
Publicker, others		250
Total		484

POLYETHYLENE: First billion-lb. plastic? Brand-new linear species should make the difference.

Polyethylene Production (1957): 680 Million Pounds (Est.)

Source (1956)	%
Conventional, high pressure process	100

Rigid, heat-resistant linear grade will open up new poly markets— and widen old ones.

End Uses (1956)	%
Film & sheet	27
Injection moldings	16
Wire & cable insulation	11
Pipe	9
Laminates	5
Bottles & tubes	4
Export	21
Misc.	7

Rarely has so much capacity been built so fast for a new product as it has for linear polyethylene.

Producer	Location	Capacity (Million Lb.)
Conventional Polyethylene		
Allied Chemical & Dye	Tonawanda, N. Y.	20
Dow Chemical	Freeport, Tex.	25
Du Pont	Orange, Tex.	200(90 [1])
Koppers	Port Arthur, Tex.	25
Monsanto Chemical	Texas City, Tex.	65
National Petrochemicals	Tuscola, Ill.	100
	Houston, Tex.	75 [2]
Spencer Chemical	Orange, Tex	90
Texas Eastman	Longview, Tex.	55
Union Carbide	S. Charleston, W. Va.	70
	Texas City, Tex.	60
	Seadrift, Tex.	60
	Torrance, Calif.	60
	Whiting, Ind.	72 [2]
		977
Linear Polyethylene		
Allied Chemical & Dye	Tonawanda, N. Y.	10
Celanese	Houston, Tex.	40
Dow Chemical	Bay City, Mich.	? [1]
Du Pont	New Orleans, La.	? [1]
W. R. Grace	Baton Rouge, La.	50
Hercules Powder	Parlin, N. J.	30
Koppers	Kobuta, Pa.	25
	Woodbridge, N. J.	60
Phillips Chemical	Houston, Tex.	110(25 [3])
Union Carbide	Institute, W. Va.	25
	Seadrift, Tex.	30
		380+
Total		1,357+

[1] Under construction; [2] Planned; [3] Operating.

cialty position, which will help absorb new capacity slated for this versatile intermediate.

Other end uses for glycol are explosives (4.7%), cellophane (2.9%), Dacron and Mylar (1.6%), exports (5.8%) and miscellaneous (8.1%).

▶ **Ethyl Alcohol**—Ethyl alcohol is facing heavy competition both as a product and as a raw material. Still, in 1956, it held its place as the second largest ethylene derivative, accounting for about 25% of U. S. ethylene consumption.

One previously important ethanol-based process, production of ethyl chloride, has been displaced by the direct process to make it from ethylene. But direct-oxidation route to oxygenated C_2 aliphatics continues to be important. Three Celanese plants at Bishop and Pampa, Tex., and Edmonton, Alta., are producing acetaldehyde and its derivatives in large quantities from ethyl alcohol.

Ethyl alcohol in brake fluids has essentially been eliminated by the trend to heavy-duty brake fluids that are formulated with higher boiling materials. Isopropyl alcohol, which can be used for many of the solvent applications, continues to capture markets from ethyl alcohol when the price differential between the two materials gets out of line.

▶ **Tough Years Ahead**—Despite competition, actual volume of synthetic ethanol should, by replacing fermentation alcohol, continue to grow, at least through 1961. In 1956, only 29% of the ethanol was produced by fermentation.

But at prevailing market prices, the synthetic ethanol industry is finding it tough to build new plants. While a general price increase occurred this year, the adjusted prices do not provide sufficient margin to encourage new plants. If the market cannot allow further price increases, the expansion in synthetic alcohol capacity will likely come from additions to existing plants.

▶ **Derivatives Are Weak**—Too, acetaldehyde and its derivatives, which consume the bulk of industrial ethanol, are in a weak position.

Most acetate is consumed in the form of fiber, and, to a lesser extent, in cellulose acetate and modified cellulose acetate plastics. Acetate fiber has been affected by the general and longstanding textile decline and by competition from other fibers, particularly the synthetics, nylon, Dacron and Dynel.

A new modification of cellulose acetate—cellulose triacetate—has been introduced by Celanese, but it is too early to conclude whether this product will strengthen the acetate fiber market appreciably.

► **Processes Boost Poly**—Much interest in new ethylene sources and in construction of new ethylene-derivatives plants focuses on one product—polyethylene.

Of particular interest is the introduction of the "linear" forms of polyethylene, as represented by new plant facilities based on the Ziegler, Phillips or other processes. These products, having a higher softening temperature, greater rigidity and higher gloss, should go into markets augmenting those which support the growth of "conventional" polyethylene.

New polyethylene plants have been announced with such rapidity that this material is now one of the major new investment categories of the chemical industry. Consumption has soared, although the rate of new construction suggests considerable overcapacity until new outlets are developed.

► **Research Spawns Markets**—Market growth should be stimulated by price reductions which may become possible as a result of larger operations and new manufacturing techniques which minimize problems of catalyst removal, solvent recovery and other cost factors.

Although some overlap is apparent in uses of conventional and linear polyethylene, such as pipe and molded articles, there is little question that substantial product-development campaigns will yield rewarding new outlets for each product.

► **Styrene: New Route Looms**—Styrene accounted for 10-12% of the ethylene used in 1956. But this ethylene market may be threatened by process advances.

STYRENE: Benzene alkylate may have to make room for reformate ethylbenzene as source.

Styrene Production (1957): 1.2 Billion Pounds (Est.)

Source (1956)	%
Ethylbenzene via benzene alkylation	100

Most styrene now goes into GRS rubber despite growing use of oil extenders in rubber polymers.

End Uses (1956)	%
Polystyrene	40.0
GRS rubber	43.9
Styrene-butadiene latex	4.8
High-styrene resins & plastics	4.3
Polyester resins	1.6
Styrenated alkyds	0.8
Other resins	1.7
Misc.	2.9

Sharp price break for styrene monomer in 1957 slows further capacity buildup.

Producer	Location	Capacity (Million Lb.)
From Ethylene		
Dow Chemical	Freeport, Tex.	285
	Midland, Mich.	200[1]
Foster Grant	Baton Rouge, La.	105(40[3])
Koppers	Kobuta, Pa.	160
Monsanto Chemical	Texas City, Tex.	240
Odessa Styrene	Odessa, Tex.	40[3]
Shell Chemical	Torrance, Calif.	135
Union Carbide	Institute, W. Va.	65
		1,230
From Acetylene		
American Cyanamid	Fortier, La.	40[4]
From Ethylbenzene		
Cosden Petroleum	Big Spring, Tex.	20
Total		1,290

[1] Includes vinyl toluene capacity; [2] Planned; [3] Under construction; [4] Methyl styrene.

A new process introduced by Cosden Petroleum recovers ethylbenzene directly from catalytic reformate, avoiding the need to synthesize this styrene intermediate from ethylene and benzene. If the process proves economic, a vast new source of byproduct ethylbenzene lies in cat reformate.

An important event in the styrene industry in 1957 was the sharp price reduction of monomer from about 17¢/lb. to about 13¢/lb. This price reduction has discouraged potential captive producers of styrene monomer because economics of production in new plants are not attractive.

► **Markets Look Good**—Markets are dominated by outlets in

VINYL CHLORIDE: Acetylene, ethylene remain prime sources because of process interdependence.

Vinyl Chloride Production (1957): 620 Million Pounds (Est.)

Sources (1956)	%
Acetylene	56
Ethylene	44

Vinyls—whose uses range from flexible film to rigid pipe—still lead all resins in volume.

End Uses (1956)	%
Plastics	99
Fibers	1

Vinyl chloride capacity jumps 60% since 1954—in tune with petrochemical confidence.

Producer	Location	Capacity (Million Lb.)
From Acetylene		
Allied Chemical & Dye	Moundsville, W. Va.	60(30[1])
Diamond Alkali	Houston, Tex.	50[1]
Dow Chemical	Freeport, Tex.	40[2]
General Tire & Rubber	Ashtabula, Ohio	40
B. F. Goodrich	Louisville, Ky. / Calvert City, Ky.	175
Goodyear Tire	Niagara Falls, N. Y.	45
U. S. Rubber	Painesville, Ohio	50
		460
From Ethylene		
Diamond Alkali	Houston, Tex.	30
Dow Chemical	Midland, Mich.	75
Ethyl Corp.	Baton Rouge, La.	40[1]
Union Carbide	S. Charleston, W. Va.	?
		145+
From Acetylene and Ethylene		
Monsanto Chemical	Texas City, Tex.	60
Union Carbide	Texas City, Tex.	180
		240
Total		845+

[1] Proposed; [2] Under construction.

GRS rubber and polystyrenes, which use about 86% of the styrene monomer. Good growth is anticipated for both outlets, even though styrene in GRS rubber has been adversely affected by the use of low-cost oil to extend rubber polymers. This use of oil probably will not mature until 1961-1962.

Polystyrene plastics markets have improved since introduction about five years ago of modified polystyrenes with improved impact resistance and other strength characteristics. Modified and straight polystyrene have an established place in the plastics market because of their cheapness, clarity and hardness, and are in good position to withstand competition from the new linear polyethylenes.

▶ **Ethylene Dichloride**—Ethylene dichloride production in 1956 totaled 613 million lb. Approximately 60 million lb. was by-product material from the chlorohydrin ethylene oxide process. About 70% of the ethylene dichloride made was consumed in vinyl chloride monomer; most of the remainder found use as a scavenging agent in tetraethyl lead formulations.

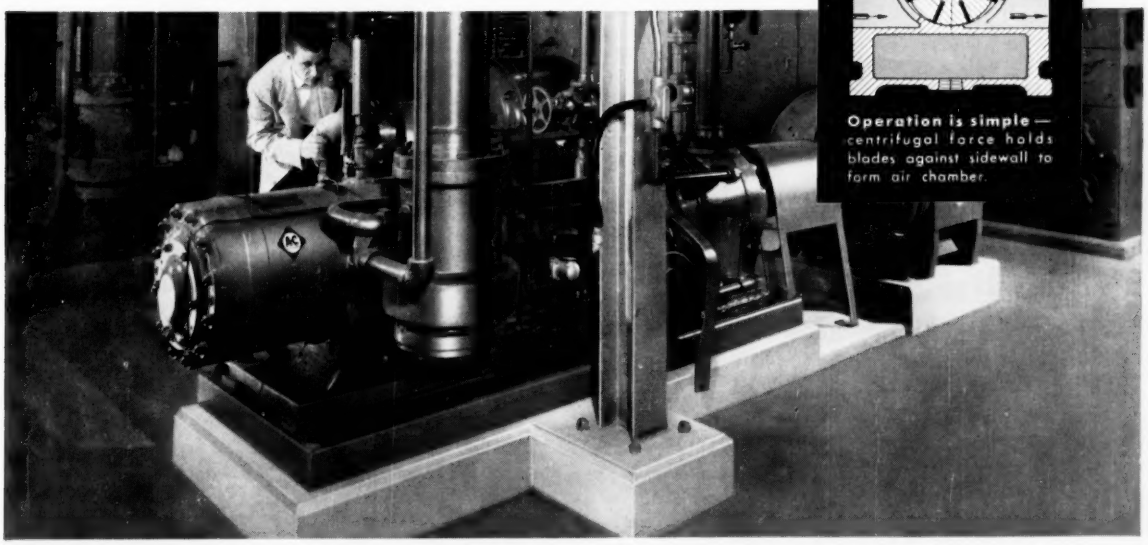
About 44% of the 1956 vinyl chloride monomer production of 597 million lb. was produced from ethylene dichloride; the remainder was made from acetylene. Practically all vinyl chloride monomer went into polyvinyl chloride and copolymer plastics, with less than 1% moving into fibers. The versatile vinyls led all other resins in volume during 1956 and have found increased use in a variety of applications from flexible film and sheeting to rigid pipe and fittings.

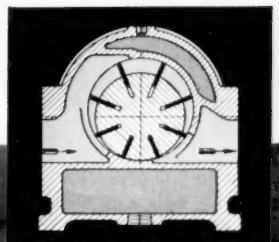
▶ **Monomer Routes Shift**—Production of vinyl chloride monomer by the dehydrochlorination of ethylene dichloride involves the simultaneous production of substantial amounts of byproduct hydrogen chloride. The acetylene route to vinyl chloride involves direct reaction of hydrogen chloride with acetylene and produces no byproduct chlorine products.

Marketing or utilization of byproduct acid from the dichloride process are frequently difficult. This has been responsible for the emergence of combined plants where a chlorine balance can be achieved.

Combined plants use hydrogen chloride released from the ethylene stage for subsequent reaction with acetylene to produce additional monomer. Both Monsanto Chemical and Union Carbide employ the combined route at Texas City, Tex. Dow Chemical has under construction at Freeport, Tex., an acetylene-based polyvinyl chloride monomer facility which will probably utilize byproduct acid from its existing ethylene-based plant.

Ro-Flo COMPRESSORS





Operation is simple—centrifugal force holds blades against sidewall to form air chamber.

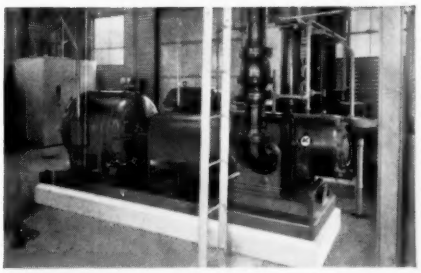
Ro-Flo units at a Midwest utility supply air for mixing with vaporized propane gas to meet an increased demand for natural gas.

No shake...no shimmy...no shock!

Rotary operation produces a remarkably stabilizing effect. You don't get the shimmy and shock inherent in reciprocating compressors.

Users in many industries have discovered that *Ro-Flo* compressors eliminate the cost of heavy foundations. A simple slab is enough. Smaller units are bolted directly to the floor. Automatic wear compensation at the rotor blades keeps compressor efficiency at high level even after years of use. There are only two wearing parts.

Ratings—Choose from twelve sizes of two-stage *Ro-Flo* compressors, ranging from 250 to 1800 cfm at pressures from 60 to 125 pounds gauge. Single-stage *Ro-Flo* units handle pressures up to 50 pounds gauge, and handle volumes from 40 to 3000 cfm.



Two-stage *Ro-Flo* compressor, installed in natural gas pipeline booster station. Unit provides make-up gas to help maintain line pressure for peak loads.

Mobile *Ro-Flo* compressors used on emergency equipment for fighting oil tank fires at a Texas oil storage area.

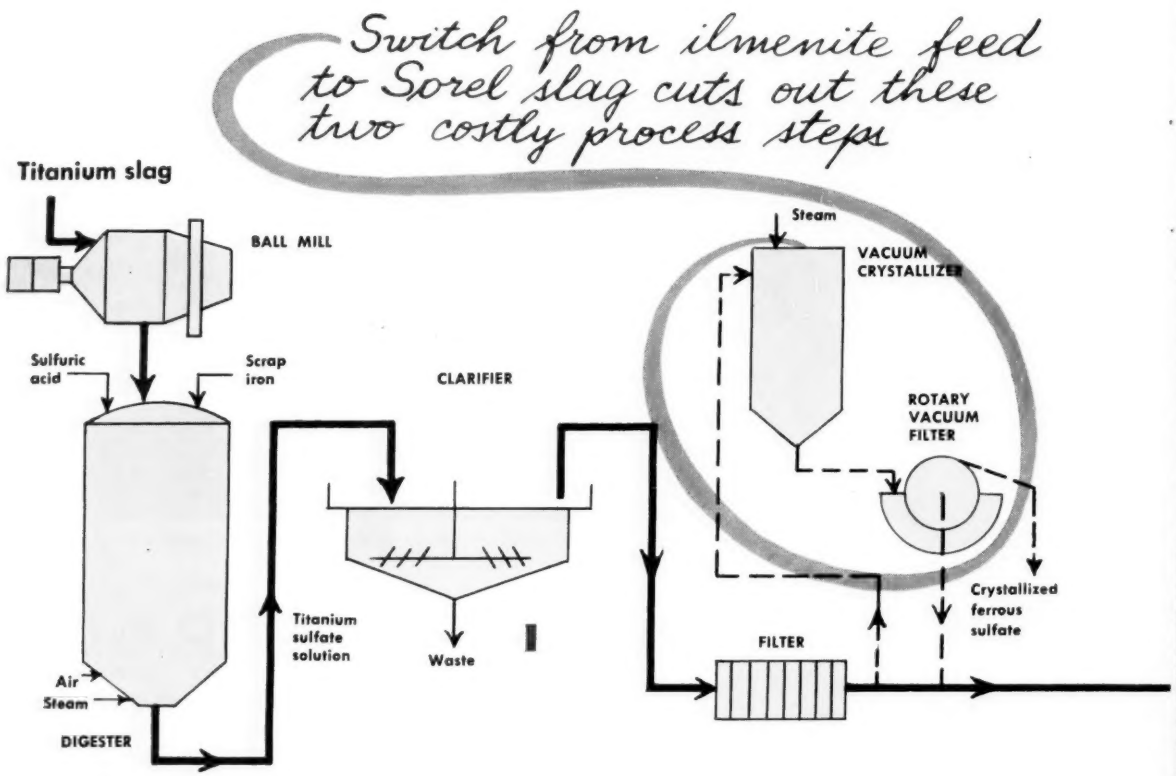
For complete information on Allis-Chalmers rotary compressors, ask for two-stage Bulletin 16B8244 or single-stage Bulletin 16B8126. Call your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

Ro-Flo is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5610



TiO_2 Process Taps Sorel Slag for Savings

IN THE well established titanium dioxide business, one producer's flowsheet is more than likely to be congruent with another's. Now Canadian Titanium Pigments has swung on stream at Varennes, Que. a plant boasting a number of process differences that reap substantial installation and operating savings.

Chief among them: CTP's use of Sorel slag instead of ilmenite concentrate as the titanium-bearing feed material. Because of the slag's greatly reduced iron content—about 8% compared with ilmenite's 30%—CTP can eliminate at least two costly process steps (*see above*) commonly needed to remove iron impurities. Moreover, slag offers a TiO_2 content around 70% by weight as contrasted with 55-60% in ilmenite concentrates. And this means that CTP can exploit its process volume more fully.

With a capacity of about 20,000 tons/yr., the installation, in operation since September, makes Canada virtually self-sufficient in titanium pigments. Canada's first white-pigment producer, plant will feed hungry Canadian paint, paper, rubber and plastics industries formerly satisfied by U. S. imports.

▶ **Takes Sulfate Route**—Route followed by CTP and preferred almost exclusively in the U. S. is the sulfate process. It involves dissolving slag (or ilmenite) with sulfuric acid, then precipitating TiO_2 from sulfate solution by thermal hydrolysis.

Most important single step in making pigment is hydrolysis of sulfate solution. For it's here—in adding sulfate solution to water—that limits are set on final product yield and quality.

When hydrolyzing, it's critically important to form proper colloidal nuclei. If sulfate stream is mixed with water at too fast a rate, an adequate colloid phase does not form. Too slow a rate gives a yield of unfilterable colloids.

Unfold Flowsheet

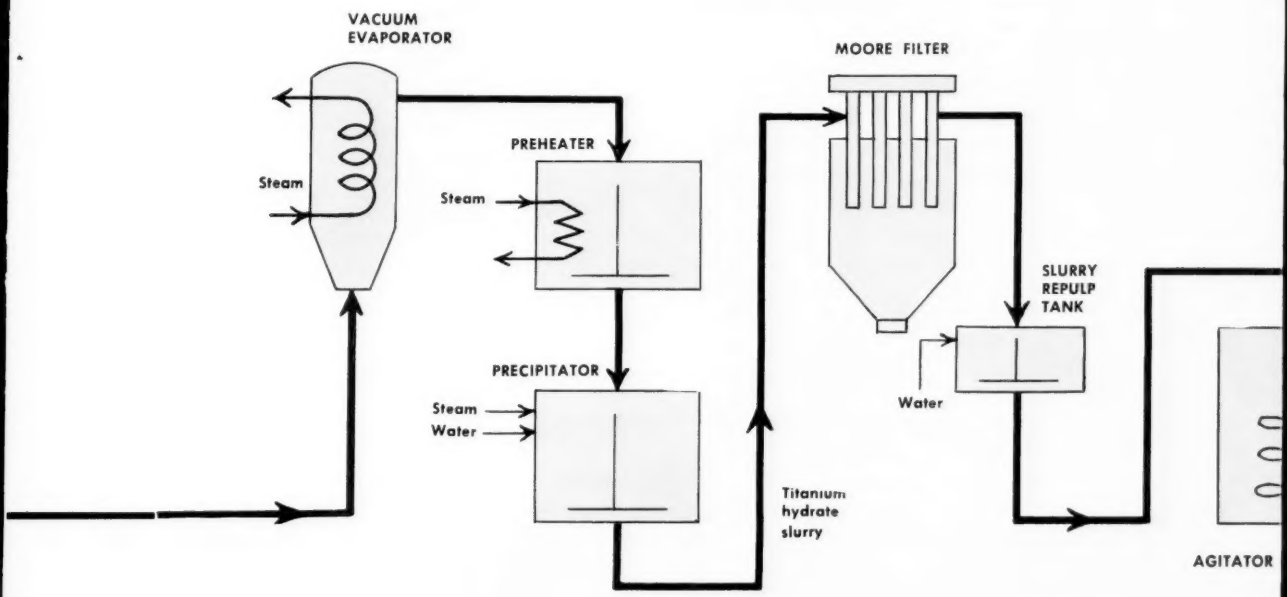
And to improve final pigment qualities, conditioning agents (e. g., oxalic acid, phosphoric acid, alkaline earth oxides) are added during this step.

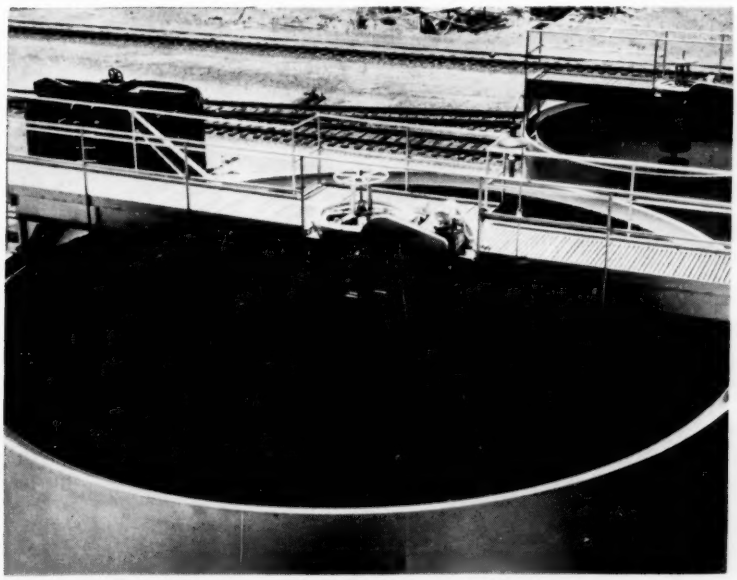
▶**How Process Works**—Concentrated sulfuric acid from CTP's own contact plant on the site, is mixed with 200-mesh Sorel slag and a little water in an air-agitated, lead-lined digestion tank roughly some 30 ft. high by 12 ft. dia. Steam heats the mixture to 110-120 C. to initiate the highly exothermic reaction.

Mixed titanium and iron sulfates, a honeycombed dry mass because of air agitation, are then dissolved in dilute sulfuric acid in the digestion tank. Excess scrap iron, enough to convert some titanium to the trivalent state, is lowered in a basket to reduce all troublesome ferric ion to ferrous. Otherwise, ferric ion would be adsorbed on TiO_2 during hydrolysis.

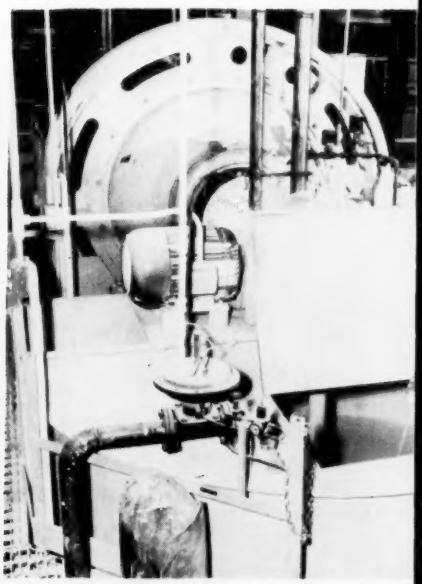
Solution then goes to a 30-ft., lead-lined clarifier where flocculants remove siliceous material and undissolved slag. Decanted liquor is filtered through a special leaf-type filter and concentrated to about 250 grams/liter TiO_2 (equivalent) and 600 grams/liter H_2SO_4 in an evaporator operating at about 27 in. of vacuum.

▶**Slag Saves Steps**—Up to this point, CTP has cut





1 **CLARIFICATION: In a lead-lined Dorr clarifier, similar to this one, impurities and unreacted slag settle out from titanium sulfate solution.**



2 **CONDITIONING AGENTS, such as a bonates or phosphates are added to boo**

out two steps usually taken in flowsheets that start with ilmenite concentrates.

For, normally, after clarification, sulfate stream is cooled and sent to a crystallizer to remove the large amount of iron impurities. Mother liquor is then filtered again before hydrolysis.

In avoiding these steps, CTP makes a tidy savings. Operating cost for crystallizer alone would run probably around $25,000-$30,000/yr.

► **The Plot Thickens**—After concentration, solution is preheated to about 96 C., then 3 volumes of solution are added to 1 volume of water at about 91 C. in a paddle-agitated tank. Agitation stops while a colloid phase forms, then is resumed and the solution is boiled for 3-4 hr. to complete precipitation of hydrated titanium dioxide. Hydrate is partly amorphous and partly anatase crystal.

Yield is 93-95%; particle size is 0.50-0.65 microns.

Actually, the above description is only representative of many variations on an esoteric theme. Every manufacturer—and CTP is no exception—jealously guards exact hydrolysis details. Particularly secret are mixing and agitation rates, conditioning agents and exact composition of sulfate stream.

► **Filteri**
is pump
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and pum

Condit
fate, an
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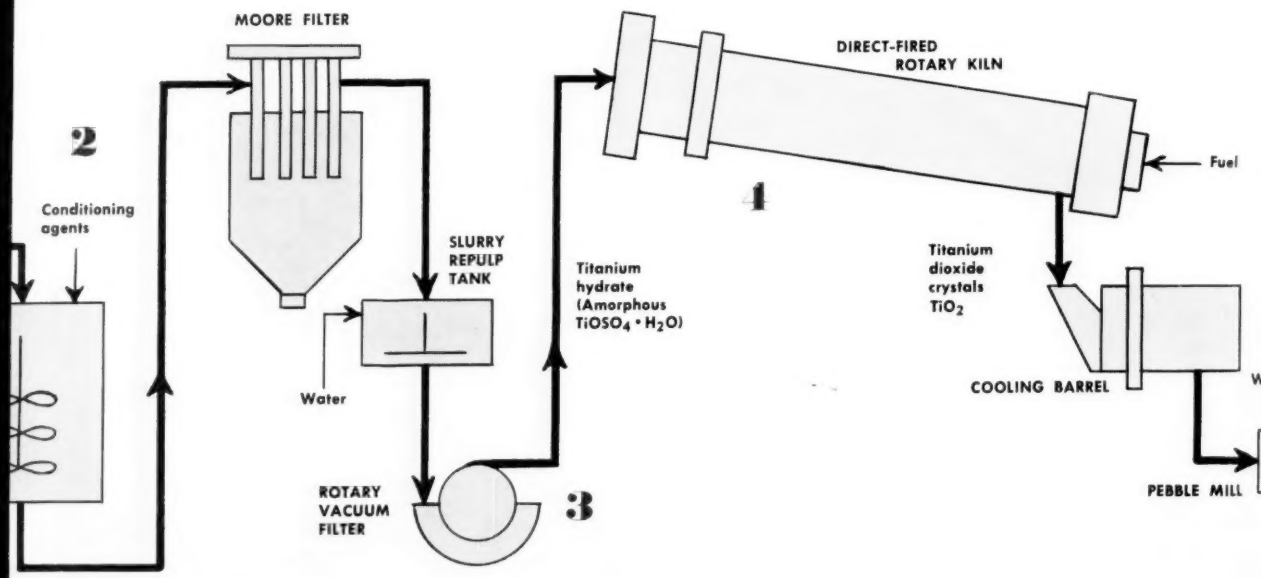
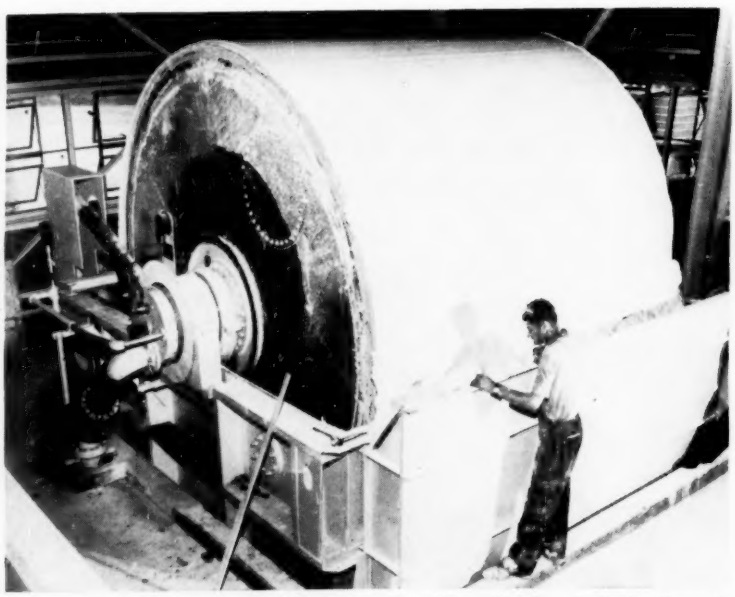
Hydra
watered
150-ft.-l

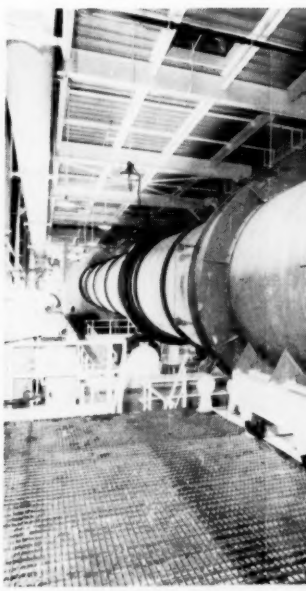
► **Kiln F**



kaline oxides, car-
t pigment quality.



3 **DEWATERING: After filtering and washing, titanium hydrate slurry is pumped to rotary vacuum filter to be dewatered before going to calciner.**



4 **CALCINING, to convert an dioxide, is done in 150-ft.-l**

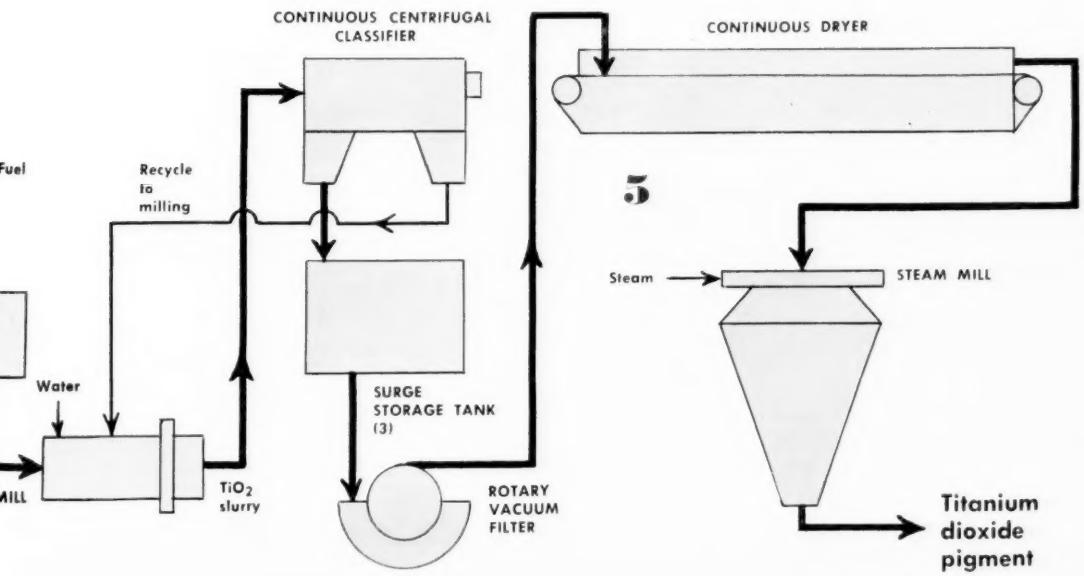
Filtering, Washing—Slurry from precipitation tank pumped to a battery of modified Moore filters, shed, repulped with water and dilute sulfuric acid d pumped to a propeller-agitated conditioning tank. Conditioning agents added here (e. g., titaneous sul-e, antimony trioxide, alkali and alkaline earth des, phosphates and carbonates) improve pigment ality and help remove last traces of iron.

Hydrate, once more filtered and repulped, is de-tered in a continuous vacuum filter and fed to a -ft.-long kiln to be calcined.

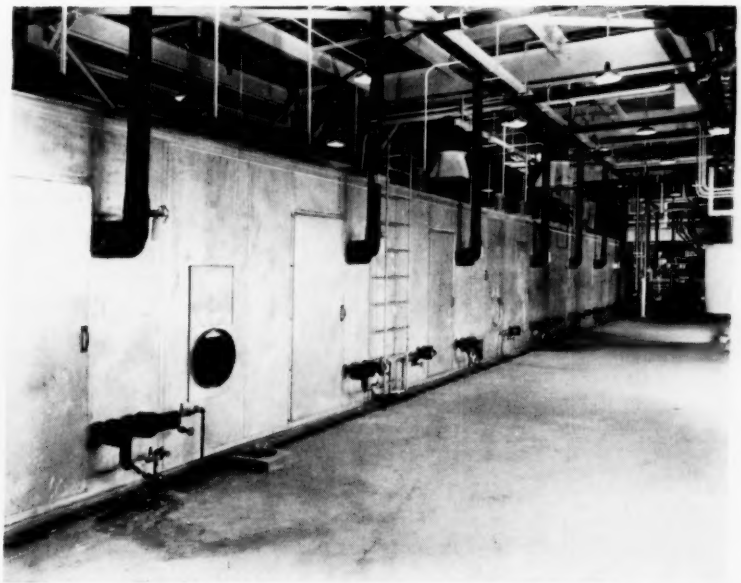
Kiln Forms Crystals—Calcining drives off traces of water and sulfuric acid and sets the pigment's final crystal form and opacity, boosting refractive index from about 1.7 to 2.5.

Hydrate ($TiOSO_4 \cdot H_2O$) is screw fed to kiln and calcined above 900 C. for about 24 hours. Hot, crystalline (anatase) TiO_2 is cooled and slurried with water and dispersing agent such as alkaline silicate or phosphate for wet grinding and classification.

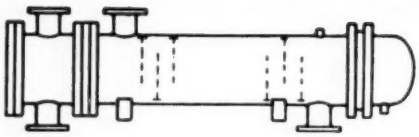
After final filtration in a continuous vacuum filter, pigment is dried and ground by steam milling to 0.3-micron average diameter. Finished pigment is sent to storage and bagging.



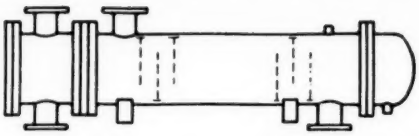
t amorphous hydrate to crystalline
-ft.-long rotary kiln above 900 F.



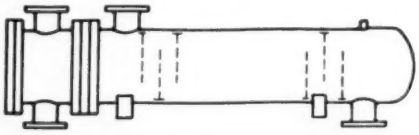
5 DRYING: Last step before final steam milling and packaging is drying TiO_2 in large continuous dryers under closely controlled temperature.



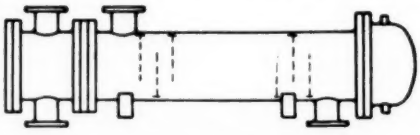
Type SG straight tube, outside packed lantern gland design. Eliminates undetected fluid inter-leakage.



Type S pull-through floating head design. For condensing, heating services . . . easy maintenance.

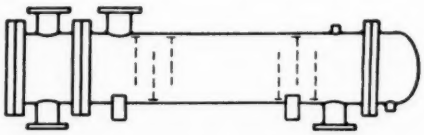


Type R U-tube design. Low cost construction, for non-fouling service.



Type ST conventional straight tube, split ring, floating assembly construction.

HOW YOU CAN SAVE WITH Whitlock Standardized Heat Exchangers!



Straight tube, fixed tube sheet design. Types V and V-1 — for easy mechanical cleaning.

SAVE WORK . . . "prints for approval" can be supplied quickly for piping and other layouts.

SAVE ENGINEERING COSTS . . . our engineers will help you select a standard design suited to your requirements.

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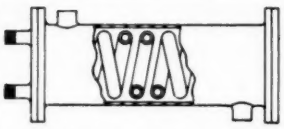
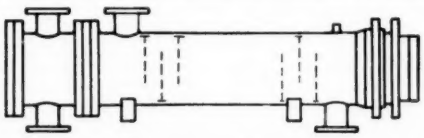
SAVE ON FIRST COSTS . . . our long manufacturing experience plus quantity produced sub-assemblies and quantity purchasing of materials reduce the unit cost of Whitlock Standard Exchangers. These savings are reflected in our current prices.

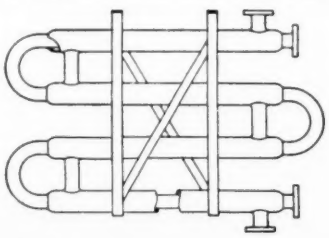
Compare costs . . . compare *savings*. It pays to consider Whitlock Standard Exchangers *first*. Send for Bulletin 250. The Whitlock Manufacturing Co., 94 South St., West Hartford 10, Conn.



Type C coil type heat exchangers. For high tube side pressures.



Floating head heat exchangers. Type SO with outside packed head — no concealed, bolted and gasketed joints.

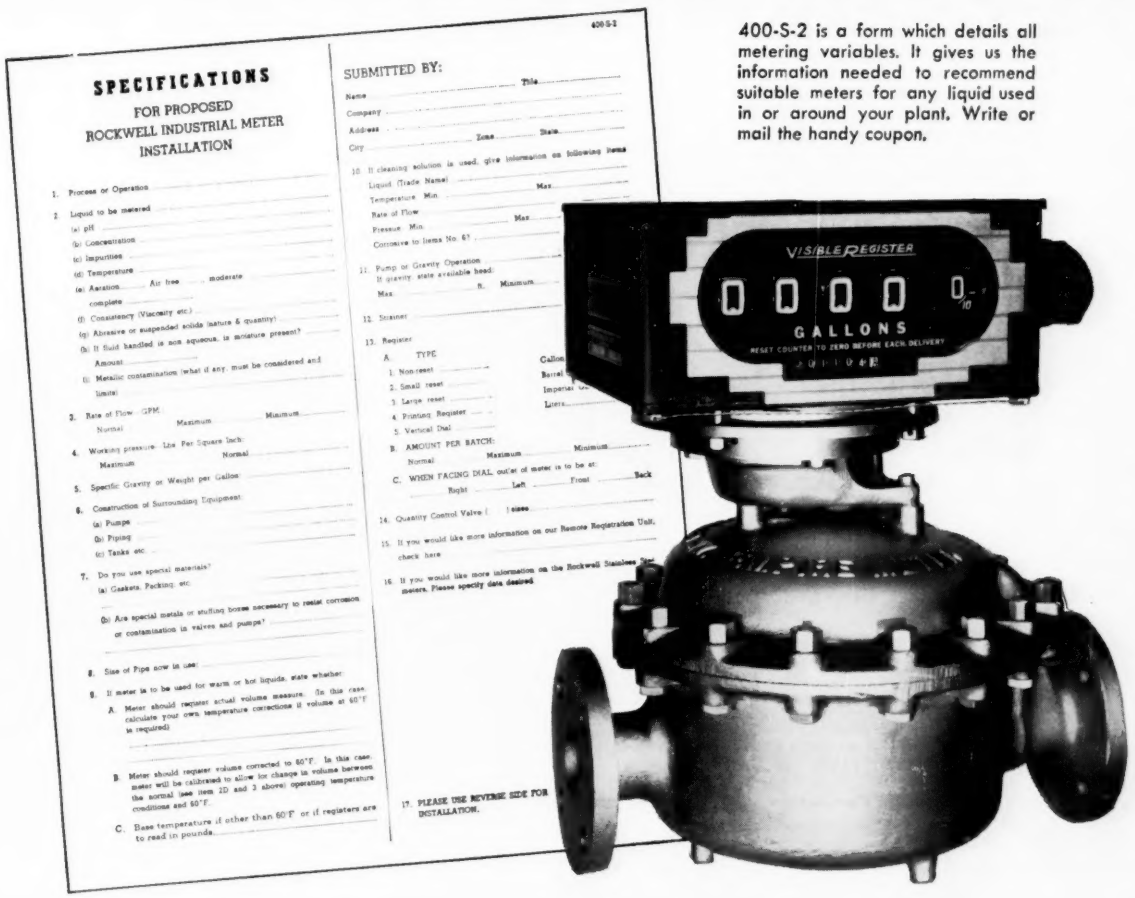


Double pipe heat exchangers. For counter-temperature flow conditions and low flow rates.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

Did You Ever Hear of 400-S-2?



400-S-2 is a form which details all metering variables. It gives us the information needed to recommend suitable meters for any liquid used in or around your plant. Write or mail the handy coupon.

If it's a liquid . . . that can be poured or piped

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Max. Flow Rate _____gpm Min. Flow Rate _____ gpm
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Company _____
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If you're coating a fine, dry material; blending liquids into a dry powder . . . or dispersing a small amount of one material into another you need more than a simple stirring, tumbling or agitating action to achieve the desired results.

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MIXING IS OUR BUSINESS

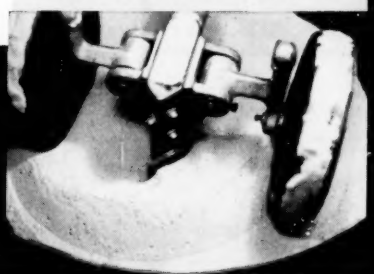
SIMPSON *MIX-MULLER*® DIVISION

National Engineering Company
634 Machinery Hall Building • Chicago, Illinois

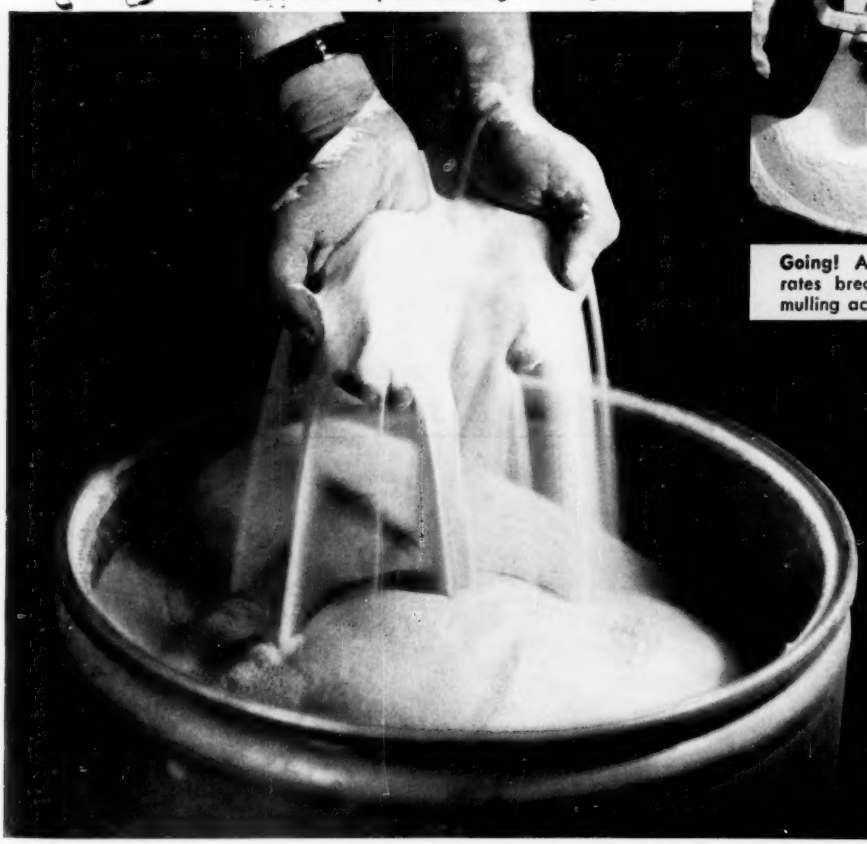
3 WAY ACTION saves time and reprocessing

Mix is wetted; dispersion of coating media begins.

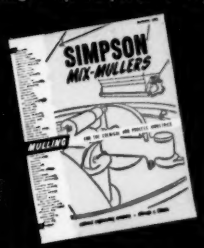
As mulling proceeds, mix begins to "lump" up as moisture is dissipated.



Going! As material drys agglomerates break down under intensive mulling action.



◀ Gone! Components are thoroughly blended. Mix is uniform, smooth flowing . . . quickly achieved.



WRITE FOR Bulletin on *Mulling for the Chemical and Process Industry.*

Chemical Engineering

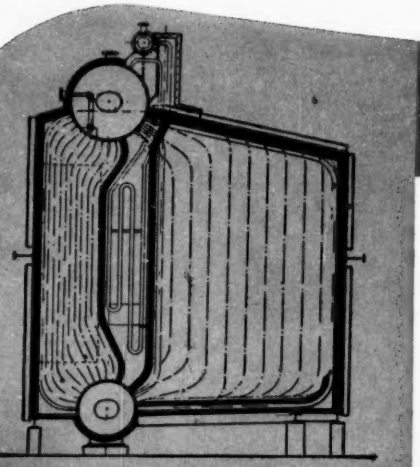
Practice

JAN. 27, 1958

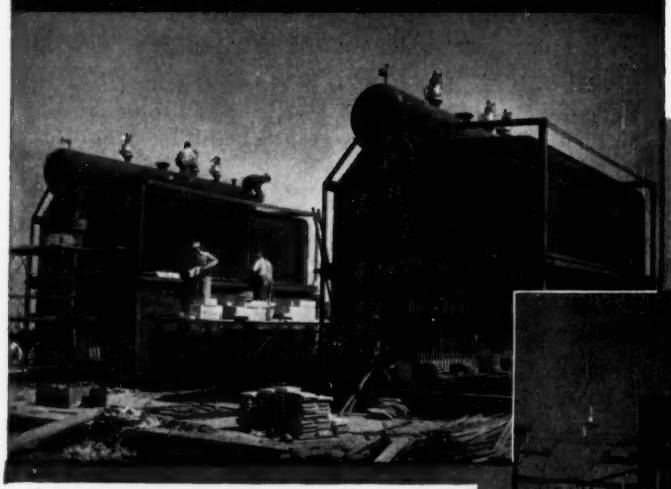
Department Index

More Steam with Fewer Dollars

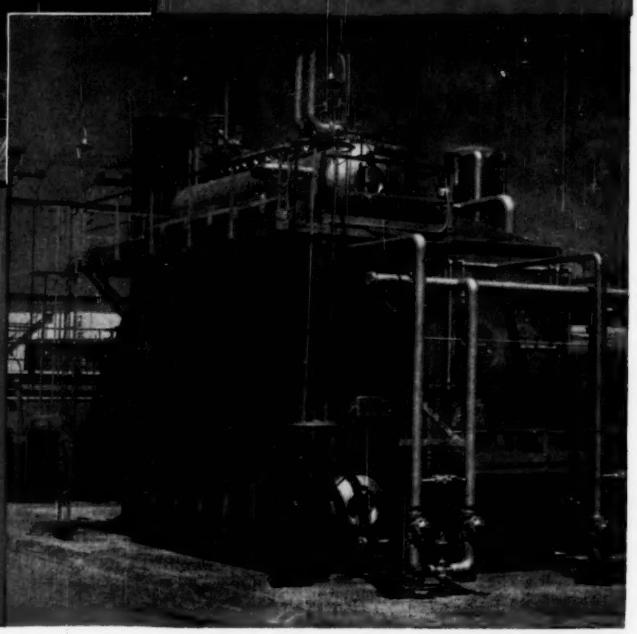
Vogt TYPE VV-S STEAM GENERATORS



Section thru Type VV-S unit.



Two 50,000 #/hr. units under erection at an Air Force Base.



A 65,000 #/hr. unit in a Texas Petroleum Refinery

- ★ Headerless construction for full unrestricted water circulation.
- ★ Large water storage capacity and correspondingly greater steam relieving space.
- ★ Long, narrow furnace ideal for oil or gas fuel.
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- ★ Simple slab foundation.
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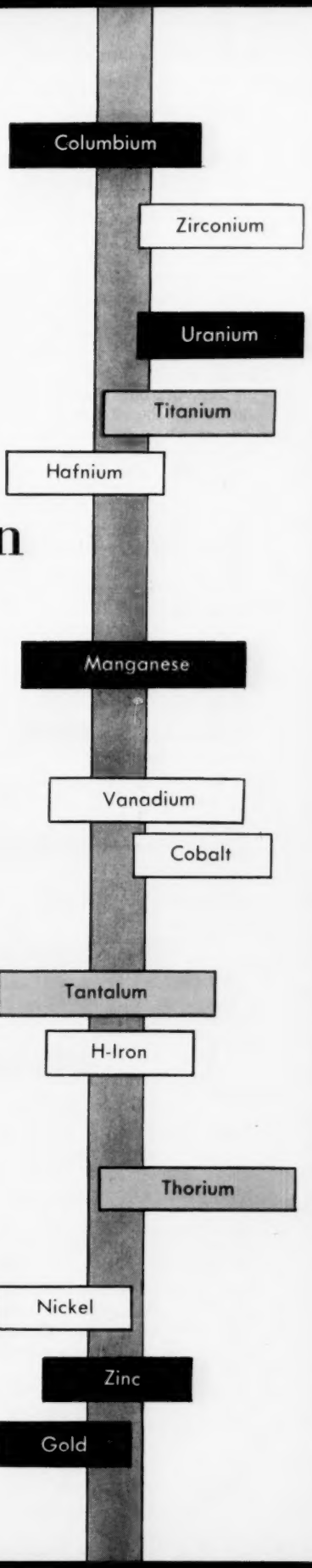
Chemical Engineering
JANUARY 27, 1958



Chemical Methods Spark Advances in . . .

Atomic-Age Metal Extraction

Chemical engineering techniques, much ignored in metal production, now solve tough corrosion, erosion, high-temperature problems in a host of new processes for making "difficult" metals.

A Chemical Engineering Report by . . .
L. W. COFFER, Battelle Memorial Institute, Columbus, Ohio

METALLURGICAL technology is advancing at a spectacular rate. We scarcely master the innovations of ion exchange, fluidized-bed reactors, pressure leaching, solvent extraction, before new metal-recovery techniques emerge.

Our atomic energy and missile programs have, of course, sparked much progress in the production of "new" metals.

But there is a broader problem which affects well known metals as well as the new materials. Metals, unfortunately, are not stockpiled by nature in easy-to-get-at stacks of ingots.

They are usually dispersed as compounds. The best ores are mined first. So each new year finds metallurgists and engineers producing greater tonnages of metal from low-grade starting materials. The new look in extractive metallurgy — sometimes referred to as chemical metallurgy — is making productive metal sources once considered impossible or uneconomical to handle (*see Chem. Eng. Award, Chem. Eng. Mid-Nov.* 1957).

• Meet your author on page 164.

Volumes could be written just to describe new processes recently developed and techniques now under development. We will attempt, here, to point out important advances and classify the newer processes from the standpoint of the chemistry and metallurgy involved.

We will discuss some of the problems that were solved and some that need solving. Very possibly these will stimulate the mind of the reader as to possible improvements that could be made in the processes discussed. Or, very possibly, many non-metallurgical processes can be improved by adapting some of the modern techniques used for extracting metals.

Metal Producers Wake Up

Many chemical companies — finding chemical metallurgy a natural extension of their normal chemical operations — are producing metals. But a number of the new processes are the result of a radical change in outlook on the part of old-line metal producers. In the past few years

they have become increasingly aware of the complexity of the processes they have to handle now, and to the need for greater knowledge of operating variables for intelligent process control.

Chemists and chemical engineers long ago discovered that until a product could be prepared in a laboratory or pilot plant there was little advantage to building a full-scale plant.

The mining industry has been generally based on one idea: if miners could get the ore out of the mine, in a reasonable state of concentration, somebody would find a way to use it.* Their watchword has been "get out the muck." This has worked well for the lead, copper, zinc, silver and gold industries. The muck usually could be handled since it was fairly high in grade.

Newer, less known materials, have presented more complex problems. During the last few years the extractive metallurgy profession has faced up to the fact that techniques were not available for handling these more reactive metals.

Much more attention is given now to development of techniques for recovering newer elements and for efficient recovery of materials from lower grade ores.

The era of research and development in extractive metallurgy is just beginning.

* There are some notable exceptions to this approach, particularly in aluminum production.

What's the First Step?

Before discussing the new methods, let's take up some of the principles behind production of a metal from ore.

Five factors greatly affect number and complexity of the operations required:

- Properties of the metal-containing mineral.
- Properties of the metal itself.
- Properties of compounds of the metal.
- Percentage of metal present in the mineral.
- Purity requirements of the metal.

Concentration or separation of the metal-containing constituent from ore is usually a first step in extraction. This is accomplished by physical or chemical means. While most recent progress has been in chemical methods, don't discount physical techniques. They have the advantage of very low costs (capital and operating) per ton of processed ore. But they are usually incapable of making complete separations (in many cases chemical operations are applied to the product of a physical concentration step). A number of new physical techniques have been recently developed.

Important Physical Methods

Grinding is a unit operation well known to metallurgists and chemical engineers. If mineral grains can be broken apart you then concentrate individual minerals by taking advantage of physical differences between grains of desired minerals and undesired minerals (gangue).

Many valuable minerals are heavier than sand grains or other gangue materials. They are separated by jigs, wet or air tables, heavy media, cyclones, spirals, or other equipment on the basis of differences in density.

Ore particles are also susceptible to magnetic forces. Mineral grains having high magnetic susceptibility are strongly attracted by weak magnetic forces, while others with low magnetic susceptibility are attracted only by a very strong magnetic force and still others seem to be unaffected in the magnetic field. Separations, therefore, can be made by passing the minerals through magnetic fields of differing intensities. Examples are the separation of magnetite from gangue or of wolframite from monazite and the monazite from cassiterite at increasing magnetic intensities.

Other ores can be separated by

Sulfuric Acid Leach Widely Used for Uranium

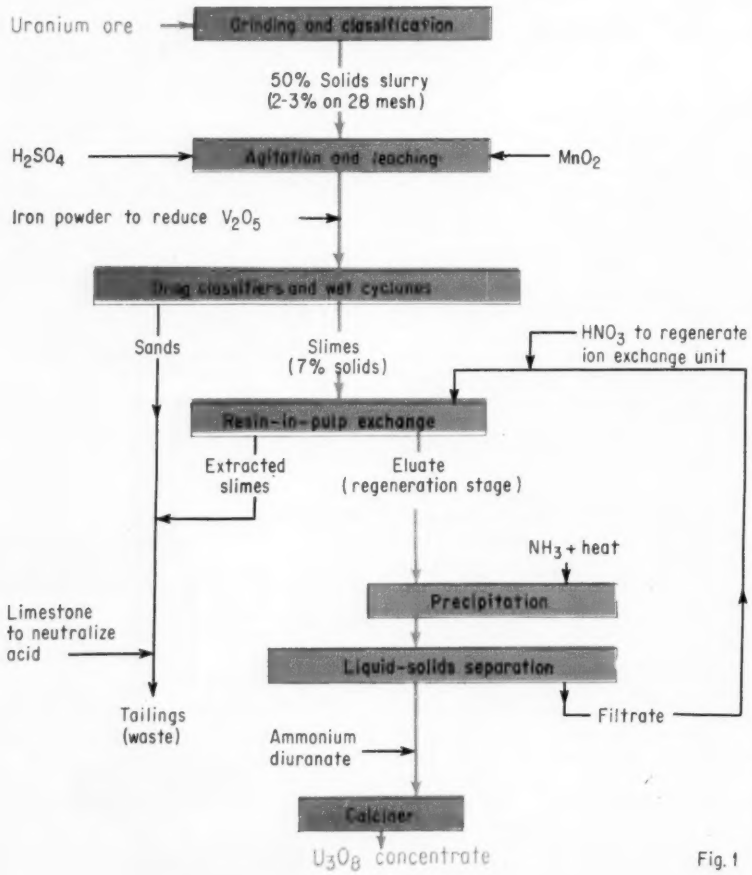


Fig. 1

electrostatic charge. Some minerals become electrically charged passing through an electrostatic field. They may be held to the surface of an oppositely charged roll over which they pass, while the uncharged particles fall away from the roll.

Some electrostatic separations are based on differential electrical conductivity of individual minerals. Particles are charged in an electrostatic field so all cling to an oppositely charged roll. As the particles move out of the field, however, those with higher electrical conductivity lose their charge by leakage to the roll. They no longer cling to the roll and are thrown off.

Selective wetting on the surface of a mineral particle is also used widely in making physical separations of mineral grains. This is the basis of all flotation techniques.

Minerals such as sulfides are preferentially wetted by oil in a dispersed oil-water system, while the gangue minerals, such as sand or quartz, are preferentially wetted by water. When air is introduced as fine bubbles into such a system, the oil-wet particles surround the air bubbles and are carried to the top for separation. Water-wet particles remain in the bulk of slurry. This selective wetability is helped along with various reagents. By their use it's possible to separate mineral grains unaffected by other separation methods.

Physical separations are seldom perfect. But often they are the only economical means of concentrating a valuable mineral.

There is a definite advantage to physical concentration if value of the mineral lost in a physical separation is less than the increase in cost incurred in treating the bulk ore.

After Physical Methods?

A chemical separation step is usually applied to a product of the concentration operation. This separates the metal, usually as a chemical compound, from the bulk of gangue that was not eliminated in the concentration step. It may be accomplished by leaching (dissolving the metal compound in a solution), by smelting (heating the mineral, usually in the presence of a reducing agent and fluxes, until the mixture is molten and the desired metal or compound separates as a liquid layer), or by vaporization of the metal or one of its volatile compounds.

Purification of separated material is often required to eliminate minor amounts of contaminants. A reduction step is then applied to the purified compound to produce metal. Further purification of the reduced metal depends on properties of the metal and the final impurity tolerance.

Chemical treatment of ores or concentrates is referred to by metallurgists as pyrometallurgy or hydrometallurgy: reactions at elevated temperatures or with solutions of reagents at lower operating temperatures.

Chemical Metallurgy Covers a Wide Field

Hydrometallurgy		Pyrometallurgy
Acid leaching	Alkaline Leaching	Roasting
Sulfuric acid	Sodium carbonate	Smelting
Nitric acid	Ammonium carbonate	Thermite smelting
Hydrochloric acid	Caustic soda	Volatilization
Hydrofluoric acid		Chlorination

Advances in Hydrometallurgy

Ion exchange, solvent extraction, pressure techniques, are revolutionizing acid and alkaline leach treatment processes.

What actually is a hydrometallurgical process? It involves reacting ore with a liquid solvent which dissolves the valuable constituent. Gangue is removed by filtration or other solids-liquid separation techniques.

The method to use in leaching a metal or metallic compound is one which will extract the most metal at the lowest cost. This is figured on the basis of cost of the process plus value of the metal left in the extracted residue. An inexpensive leaching reagent that leaves much of a valuable metal in the residue may be less economical than a more expensive reagent that recovers more of the metal. If the leaching agent can be recovered for re-use at relatively low cost, a somewhat more expensive reagent is justified.

Acid Leaching: Widely Used

Leaching reagents fall into the chemical classification of acids, salts, or bases. The four acids most commonly used now for leaching are sulfuric, nitric, hydrochloric and hydrofluoric.

Most Important: Sulfuric Leaching

Sulfuric leaching is widely used, probably because sulfuric acid is the cheapest mineral acid. One of the oldest practical uses of sulfating is in the leaching of copper ore with acid mine water followed by cementation of the copper on iron. This was followed by leaching mine tailings with sulfuric acid (produced from roaster gases) and recovery of copper.

Today, sulfuric acid is used extensively for recovery of uranium in the U. S. and in the Blind River district in Canada.

Uranium ore is mixed with water and ground in ball mills to liberate the film of uranium mineral which clings tightly to the ore sand grains.

Sands and slimes (finely ground mineral particles) may be separated by wet cyclones and the sands discarded, or the whole slurry may be made acid to a pH of 1.0 or lower by adding sulfuric acid. Oxidizing agents such as manganese dioxide are used to oxidize any pitchblend or urananite (U_3O_8) to more soluble UO_3.

Uranium goes into solution as a

complex uranyl sulfate in which uranium occurs as the negative ion.

It may be recovered by filtration from the gangue and precipitated by caustic. This direct chemical precipitation method at one time accounted for almost all U. S. uranium production. But the technique is not very selective for uranium and complicated purification steps are necessary. Precipitation is fast fading out of the picture, giving way to two techniques little used in extractive metallurgy until recently: ion exchange and solvent extraction.

Ion Exchange Enters Metallurgy

To date the most widely used process for removal of uranium from solution involves columns of anion-exchange resins. These resins preferentially extract uranyl sulfate complex ions (or uranyl carbonate complex ions). Ion exchange accounts for about 61% of all the uranium produced in this country.

When the ion-exchange resins are saturated with uranium, the adsorption process is reversed by passing an "eluant" solution containing nitrate or chloride over the resin bed. Uranium appears in concentrated form in the eluant, from which it is recovered by precipitation with ammonia or caustic soda. The product is relatively pure sodium or ammonium diuranate; recovery is close to 100%.

Process is continuous-intermittent. One column is first exposed to a large volume of pregnant solution; then washed; then exposed to a small volume of eluant; then washed again before resuming the cycle. For continuous operation a number of columns are used—some on stream, some under regeneration.

Resin-in-Pulp Improves Ion Exchange

Column ion exchangers, however, require clear liquors. This calls for high investments in filters and clarification equipment. The new resin-in-pulp (RIP) process was designed to overcome this objection.

RIP chemistry is identical to column ion exchange. However, the uranium solution does not have to be separated from undissolved residue. A slurry moves countercurrent to the resin confined inside a series of porous containers. These containers are dipped up and down in the pulp, freeing the resins of slimes. At any one time one bank of containers is on an absorption cycle, another bank on the elution cycle. Thus the RIP process avoids costly filtration. But there are some disadvantages such as high operating and capital costs—also the large resins required are costly.

Fig. 1 is a simplified plan of a U. S. commercial sulfuric acid mill, employing resin-in-pulp exchangers.[1]

Even Better: Continuous Exchange

One of the interesting new developments in this field is the use of a continuous ion exchange system which avoids disadvantages of column ion exchange and RIP.

Union Carbide Nuclear at Maybell, Colo., has just started operation of such a system (modification of an Infilco-Techmanix design).[2]

Uranium is recovered from pulp or clear liquor. On pulps, the system tolerates higher solids content than RIP, and maintenance, operating and capital costs are lower.

Resin and feed enter a contracting stage, then mix in the pipe leading to a distributor at the bottom of the tank. Air enters through a porous bottom panel, agitates and lifts the resin-pulp slurry up a central well. Overflow from this well enters a peripheral settling zone,

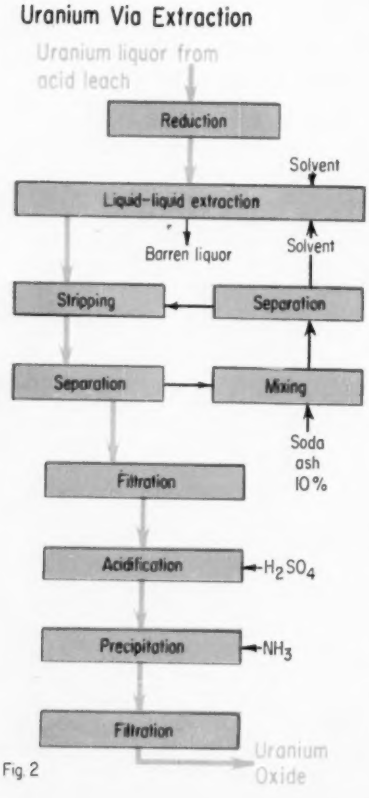


Fig. 2

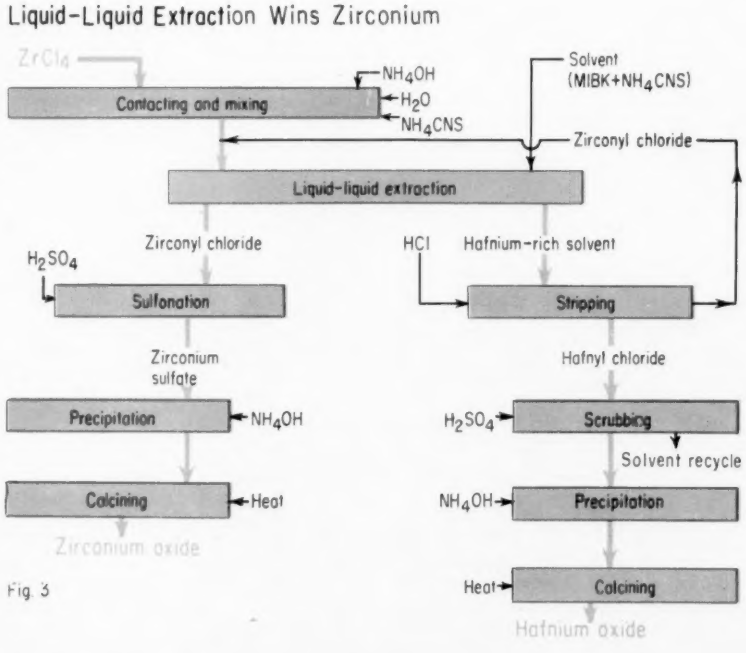


Fig. 3

where resins drop into a thickening compartment. Treated pulp discharges. The thickened resin can be recirculated or transferred to the next stage.

Solvent Extraction on the Way Up

Compared to ion exchange, solvent extraction is more widely used, as a unit operation, in the petroleum and chemical industries. Application in extractive metallurgy is a recent development. The tremendous interest now developing in solvent extraction is largely based on the successful application of this technique for the production of uranium.* Extraction permits a relatively simple, continuous operation and produces a high-grade product:

• Climax Uranium at Grand Junction, Colo., and Kerr-McGee Uranium at Shiprock, N. M., recover uranium from sulfuric acid leach solutions by extraction with 2-ethylhexyl phosphoric acid, tributyl phosphate in kerosene. The phosphate is added to prevent third phase formation, but it also acts as a synergistic agent—the extraction coefficient of the mixed reagent is greater than the sum of each alone (Fig. 2).

• The difficult hafnium-zirconium separation in the production of reactor-grade zirconium is accomplished by solvent extraction. One of the producers, Wah Chang Corp., uses ammonium thiocyanate in methyl isobutyl ketone to separate zirconium from the 2% hafnium naturally occurring in zirconium (Fig. 3).

• Also, Fansteel Metallurgical Corp., at Muskogee, Okla., is starting up a process using liquid-liquid extraction for the separation of tantalum - columbium. Previously Fansteel used fractional crystallization. The new process centers around methyl isobutyl ketone.

• Much attention is now given to improving recovery of nickel and cobalt from ammonia leaching of Cuban laterites with liquid-liquid extraction. This research is sponsored by the U. S. General Services Admin. to improve the metallurgy of the Nicaro, Cuba nickel plant.

What Is Solvent Extraction?

In extractive metallurgy solvent extraction usually consists of three major steps: extraction, stripping and recovery.

An aqueous liquor contacts an organic extractant, dissolved in a suitable carrier, with transfer of the selected component such as uranyl sulfate ion, to the organic phase. Organic and aqueous phases are then separated. In the Kerr-McGee process[3] these contactors consist of four mixer-settler extractors. Each extractor has two units: a 16-ft. dia. by 6-ft. high wooden settling tank and a 4-ft. dia. by 4-ft. high stainless mixing tank mounted inside the settling tank. Aqueous liquid flows by gravity, solvent travels uphill countercurrently via air lifts.

In stripping, loaded organic comes in contact with an aqueous solution that removes the desired component from the organic. This step gives a raffinate for discard or additional processing, a loaded strip liquor, and a regenerated solvent for re-use in the extraction step. Again at Kerr-McGee, a 10% soda ash solution is the stripping solution in a two-stage countercurrent back extraction. In the zirconium - hafnium separation, stripping agent is HCl.

Recovery can be carried out in a number of ways. The loaded liquor can be filtered, the metal precipitated and filtered, or calcined, producing the oxide.

Advances Coming in Extraction

Basic methods for metal recovery by solvent extraction closely resemble ion exchange. In fact some solvent systems developed for uranium recovery have been referred to as "liquid ion-exchange systems." The solvent gives up ions and forms complexes with the extracted material. Much work is now going on in the development of new solvents.

Solvent extraction is competing with other procedures such as precipitation, fractional crystallization, electrolysis, ion exchange. Now solvent extraction accounts for about 8% of all the uranium produced in this country, and this is expected to increase. Nevertheless, solvent extraction is not without some difficulties in metallurgy. There is always some solvent loss through solubility in aqueous solutions, emulsion formation, solvent poisoning, mechanical leakage, etc. On a per ton ore cost, solvent extraction does not appear to be as cheap as column ion exchange for low-grade ores due to solvent losses. But extraction is competitive on high-grade ores.

One interesting development is the research work now going on for direct solvent leaching of uranium ores which, if successful, might radically change the cost picture for uranium.

Three processes (all in pilot plant stages), developed under AEC contracts, involve percolation of a mineral acid-solvent-diluent system through the ore on a perforated or porous moving plate. This method eliminates many pre-

Important Separation Route: Sulfate Roasting

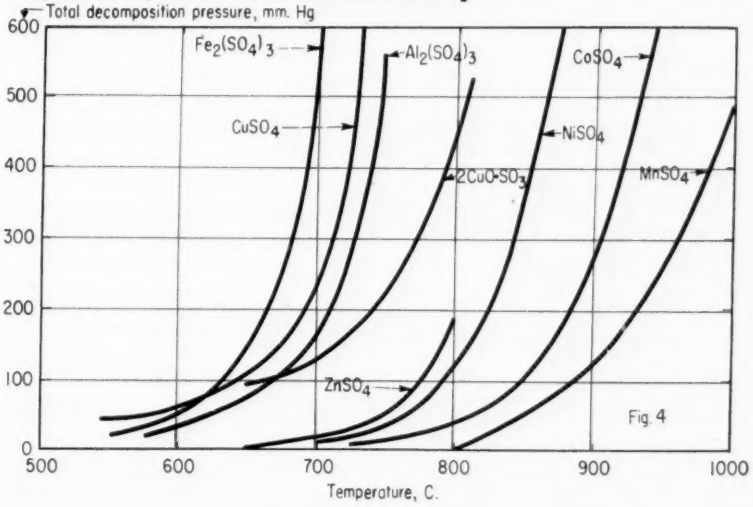


Fig. 4

* For some years now solvent extraction has been used for byproduct uranium recovery in the production of phosphoric acid.

Important New Trend: Ammonia Pressure Leaching for Metal Production

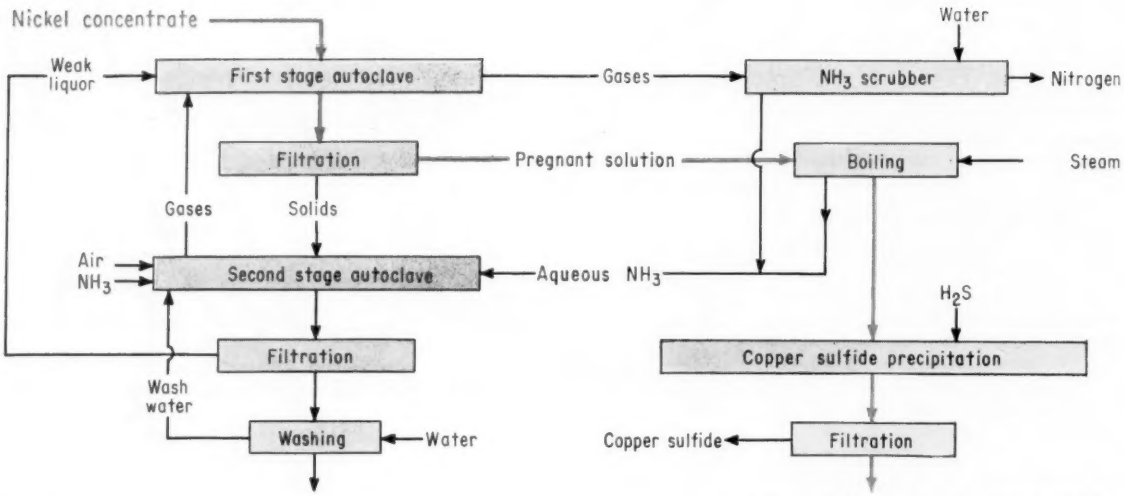


Fig. 5

liminary concentration steps. It has attractive possibilities provided solvent losses can be kept low.

Metals via Fluidized Beds

There is an entirely different approach to sulfate leaching (followed by ion exchange or solvent extraction). This is to form sulfates in a furnace, then leach out the desired material.

Sulfides of iron, nickel, cobalt, cadmium, zinc and copper form sulfates when roasted in air at controlled temperatures. At higher temperatures, depending on the metals involved, sulfates decompose so the calcine contains metal oxides.

Actually, separation of metals based on selective sulfate decomposition did not become practical until the recent perfection of a method for close temperature control during the roasting operation. This techniques centers around the use of fluidized-bed roasters.

Fig. 4 shows how decomposition pressures of a number of sulfates increase with temperature. These curves show you can decompose iron sulfate to the oxide, for example, while leaving copper, cobalt, and nickel as undecomposed sulfates. It is now possible to roast a pyrite containing small percentages of cobalt, nickel, or copper in a fluidized-bed reactor at a temperature above the decomposition point of ferric sulphate to produce a calcine. Cobalt, nickel, or copper can be leached out, leaving ferric oxide behind.

Separation has given as much as 95% or more of the desired metal while extracting less than 5% iron. Sulfate roasting is applicable to sulfide ores and to ores that can be mixed with cheap sulfur sources such as pyrite.[4]

A number of fluidized-bed roasters in the United States and in Canada, at least one in Japan, and one or more in Africa are operating to produce calcines. From these copper, nickel, zinc, or cobalt are leached, leaving most of the undesirable material in the residue. Elements occurring together in the calcine may be leached as sulfates in a water solution. The problem of separating the valuable constituent becomes one of chemical precipitation, electrolysis, cementation, solvent extraction, etc.

Pressure Leaching Gives High Yields

Another approach to sulfuric acid leaching, pressurized oxidation and leaching of minerals containing sulfides, is one of the most interesting developments in the past eight years.

Ore, or preferably a concentrate, containing high percentages of sulfur or arsenic is slurried with water and pumped into a vessel operating at elevated temperatures and pressures. Ore is oxidized by oxygen or air blown through the slurry. At high pressures (900 psig.) the increased partial pressure of SO_2, and the equilibrium attained by the reaction, both favor formation of metal sulfates. If arsenic is present, it oxidizes to arsenic acid and may appear in the leached pulp as insoluble arsenates.

Excess sulfur forms sulfuric acid and the slurry discharged from the autoclave may contain high concentrations of H_2SO_4.

The combination of high temperature, oxidizing conditions and high sulfuric acid concentration places severe restrictions on the autoclave lining and any other material in contact with the slurry. Acid-proof brick is used for linings and titanium gives satisfactory life as agitators, discharge pipes and valves. By contrast, all of the stainless steels tried have failed quickly (Fig. 6).

Calera Cobalt Refinery in Operation

The best-known example of a pressurized acid circuit in the U. S. is the leaching of cobaltite at the Calera Cobalt Refinery in Garfield, Utah.

Treated mineral is a complex cobalt-arsenite-sulfide concentrate produced from the Blackbird mine

Titanium Is Popular in Construction of Pressure Acid Leach Autoclaves

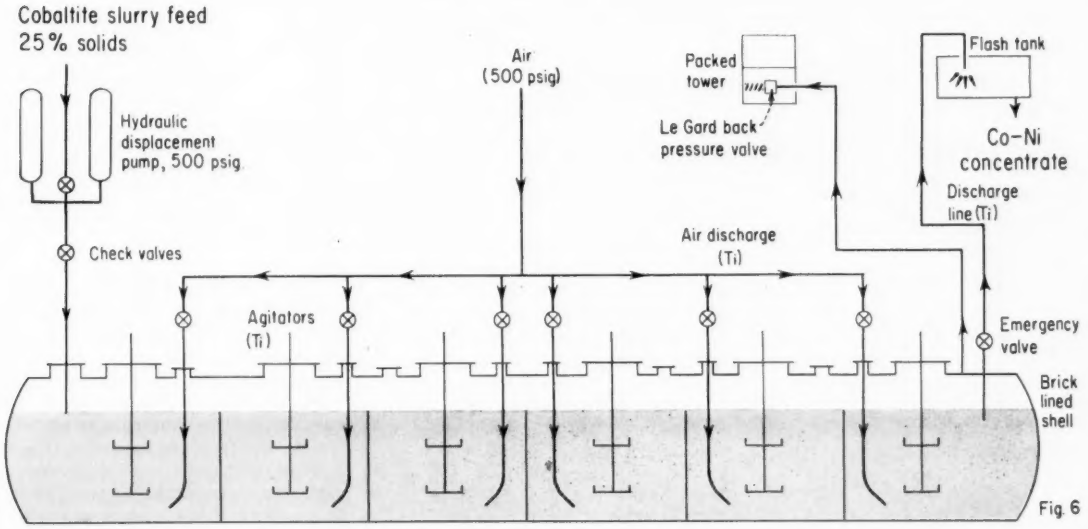


Fig. 6

in Idaho, containing 17.5% cobalt, 20% iron, 24% arsenic, 29% sulfur, 1% nickel, and 0.5% copper. The high arsenic content of the ore makes it hazardous to treat by ordinary methods.

Sufficient excess iron to precipitate the arsenic is included in the autoclave charge. Arsenic precipitates as insoluble ferric arsenate, so danger from soluble arsenic compounds is eliminated. The slurry discharges from the autoclave and excess sulfuric acid neutralized by addition of powdered limestone. Gangue and precipitated calcium sulfate are filtered off. The solution contains 95 to 97% of the cobalt and a proportional amount of the copper and nickel as sulfates with only a small amount of iron.

Calcium hydroxide and ammonia are added to the solution and air blown through it to oxidize traces of iron to ferric. Precipitated iron hydroxide carries down with it small amounts of cobalt and is filtered off to be recycled to the circuit.

Copper is removed from the filtrate by cementation on cobalt powder.

Cobalt was formerly recovered by hydrogen reduction from solution in autoclaves at about 375 F. and at 800 psi.

The hydrogen-reduced powder contained 0.15% sulfur and was melted in an arc furnace with a high-lime slag. It was poured into water to produce granules.[5]

A full-scale electrolytic plant for plating cobalt from purified leach solution was put into operation in Oct. 1957. It is capable of producing high-quality cobalt cathode sheet that meets specifications for metallic cobalt without further treatment. Comparative costs of electrolytic process and the hydrogen reduction technique are not available.

Ammonia Cuts Corrosion

Oxidation of copper, nickel, and cobalt sulfides can be carried out at elevated temperatures and pressures, in the presence of sufficient ammonia, to neutralize all sulfuric acid formed and to combine with metals to form their respective amines. Ammoniacal solutions do not attack stainless steel, so the problem of construction materials for autoclaves is simplified.

Another advantage of the ammoniacal circuit is simplification of copper removal from leach solutions. After removal of leach residue, the solution is boiled to recover ammonia and precipitate copper sulfide. Final copper removal is accomplished by addition of a small amount of hydrogen sulfide to the solution.

Prime Example: Sherritt-Gordon

A well known example of pressurized-oxidation leaching in ammoniacal solution is the Sherritt-Gordon nickel plant operated in Fort Saskatchewan, Alberta Province, Canada. A description of the process is available.[6] Fig. 5 is a simplified flowsheet.

The Ni-Cu-Co flotation concentrate leached in the Sherritt-Gordon process contains 12 to 16% Ni (chiefly as pentlandite), 1 to 2% Cu (as chalcopyrite), 0.2 to 0.5% Co (thought to be present in the pentlandite), 33 to 40% Fe (as pyrrhotite and pyrite), 28 to 34% S, and 8 to 20% insoluble.

As shown on the flowsheet, a two-stage leach is employed, with the solids from the first stage releached with a more concentrated ammonia solution in the second stage. This concentrate solution then contacts fresh ore in the first-stage leach.

Sherritt-Gordon has recently patented* the use of leaching towers operating under pressure for their process. These towers operate as pressurized Pachucas in which agitation is produced by air passing through the pulp.

Some of the difficulties associated with autoclave operation, such as erosion and maintenance of seals around the agitator shafts, are not encountered in the leaching towers.

* U. S. Pat. 2,740,707.

HNO_3 Leaching Hinges on Efficient Nitric Recovery

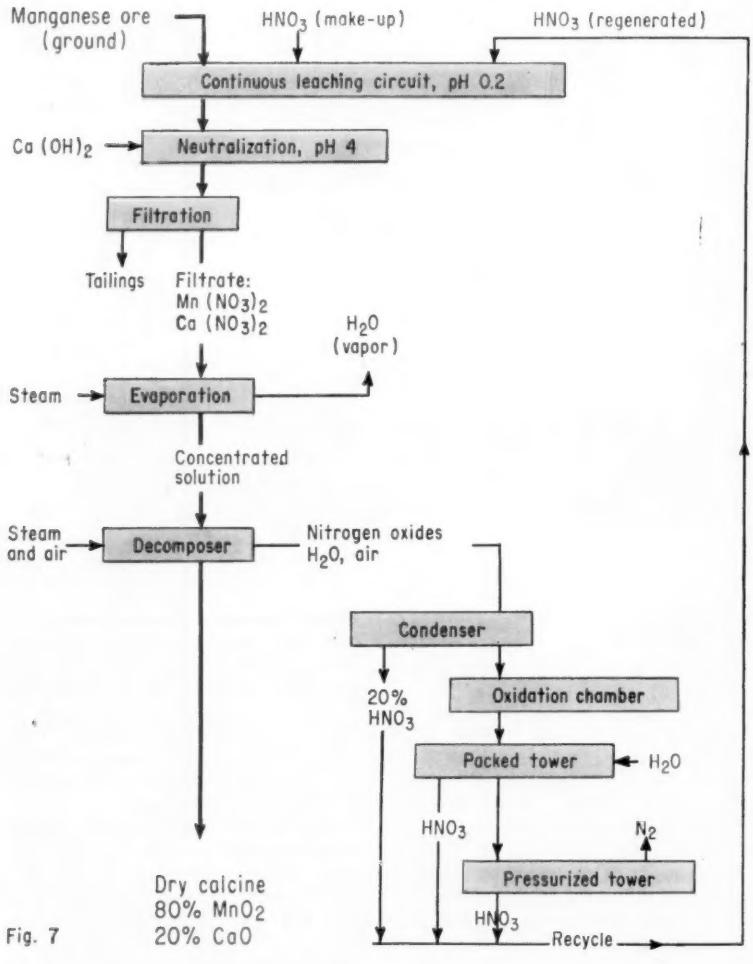


Fig. 7

These advantages probably will exert considerable influence on the design of high-pressure leaching processes for the future.

Pressure Leaching for Uranium?

A novel process for leaching of uranium, from ores containing high percentages of sulfides such as pyrite, has been suggested.[7]

Ore would be slurried with water and pumped into an autoclave operating at high pressure and at elevated temperature. Air would be blown into the autoclaves to oxidize the pyrite or other sulfide materials to give sulfuric acid as one of the products. Uranium would be dissolved in the sulfuric acid and the discharge from the autoclave filtered to remove gangue. Filtrate might be treated by usual ion-exchange methods.

A plant is under construction to operate on the suggested principle but no information is available as to the stage of its development.

Also, Consider SO_2 Leaching

Sulfur dioxide is used as the leaching reagent in the recovery of manganese in both the SO_2 process and the dithionate process.

In the SO_2 process, the ore to be reacted is suspended in water and a stream of sulfur dioxide passed through the suspension until manganese converts to sulfate. The sulfate solution is then filtered to remove gangue and evaporated to produce manganese sulfate. This is then heated to decompose into manganese oxide and SO_2 or SO_3 for recycle to the process. Process was applied on an industrial scale.[8]

The dithionate process differs from the SO_2 process in the addition of calcium dithionate to the leach solution and the recovery of manganese by precipitation from the solution by addition of slaked lime. The dithionate process has been piloted on a 400 lb./day scale at the Salt Lake City laboratory of the Bureau of Mines.

Nitric Leach Has Advantages

Nitric acid has not been a popular commercial leaching reagent because of high cost. However, interest in nitric acid treatment of ores is increasing because of the ease with which inorganic nitrates can be decomposed to metal oxides.

The nitrogen oxides produced can be recovered by passing through an absorption tower where they form nitric acid for reuse in the process. Fig. 7 is an idealized flowsheet of how the process might operate in a plant for the recovery of manganese.

Finely ground ore would mix in a continuous leach circuit with nitric acid to a pH of 0.2 to dissolve manganese. The slurry could be neutralized by the addition of lime to a pH of 4 to precipitate iron and aluminum. Manganese and calcium remain in solution as nitrates.

Gangue material would be removed by filtration and thoroughly washed to recover all possible nitrate. Filtrate could be evaporated to a specific gravity of 1.7 and the thick syrupy solution fed to a decomposition unit operating at 1,200 F. Nitrates could then be decomposed to give a mixture of manganese and calcium oxides. The manganese content of the product should exceed 50%.

No attempt would be made to remove the calcium oxide because this would act as a slag-forming constituent during the smelting of the product to manganese metal or ferromanganese.

Nitrogen oxides produced from the decomposition would pass through a condensing system and then to a standard nitric acid plant.

Economics Can Be Favorable

Reagent costs for the process are mainly for nitric acid, so a review of the nitrogen losses is important:

• A properly washed residue contains less than 0.03% nitrogen,

corresponding to a loss in makeup nitric acid of about 3.5 lb. of HNO_3/ton of ore.

• The oxide product from the decomposition of the mixed nitrate solution can be controlled to contain as little as 0.02% nitrogen. This represents no more than 0.5 lb. of HNO_3/ton of original ore.

• Nitric acid manufacturers figure recovery of nitric oxides at 95 to 98% on the basis of a 6 or 7% nitrogen oxide gas. If laboratory results, in which 75% of the nitric acid was recovered in the condenser, can be duplicated and it is possible to recover 95% of the remaining nitrogen oxides in the nitric acid plant, a loss in recovery of nitrogen oxides not exceeding 1½% of the nitric acid can be anticipated. This amounts to approximately 15 lb. of nitric acid/ton of original ore. The total evaluated losses of nitric acid is therefore 19 lb./ton of ore treated.

Unevaluated losses in dissolving the ore and evaporation of solutions of nitrates are expected to be small, so a utilization of 20 lb. of makeup nitric acid/ton of ore would seem to be a reasonable figure. A cost figure of 5¢/lb. for purchased makeup acid would give a cost of $1/ton of ore for this item.

The "nitric acid cycle" recovery of manganese from low grade domestic ores was proposed by Dr. E. S. Nossen and was piloted in 1954 in Paterson, N. J., under the sponsorship of the U. S. GSA. The pilot-plant operation was discontinued before the merits of the process were evaluated. A description by Nossen[9], and a patent issued to him[10] give most of the available information on the process.

Nitric Leach for Uranium and Nickel

Recovery of nitric acid for reuse makes the nitric acid cycle appear competitive with other leaching processes. It should be applicable to copper, nickel, cobalt, or uranium ores.

Nitric acid is the best leaching agent for uranium because it oxidizes any reduced uranium oxide and gives excellent extractions, but high cost has prohibited its use. If the uranium were recovered by ion exchange, nitric acid used in forming nitrates with basic oxides or carbonates might be recovered by evaporation of the nitrate solution and decomposition of the nitrates.

A recent patent[11] assigned to the Bethlehem Steel Corp. describes a nitric acid process for the treatment of lateritic ores containing nickel. Two alternatives are described by the patent. Each provides for the treatment of the finely divided ore with nitric acid.

One alternative provides for use of excess nitric acid over that required for nickel, iron, and other nitrate forming constituents, then autoclaving the slurry at a temperature where ferric nitrate is unstable and decomposes to ferric oxide. Ferric oxide is removed in a subsequent filtration step along with the remaining gangue materials.

The other alternative provides for the use of just sufficient nitric acid for the nickel and other nonferrous constituents of the ore and for autoclave treatment for decomposition of the nitrates formed so nickel is dissolved and iron is not. No publication has appeared indicating the extent to which Bethlehem is interested in the process.

Hydrochloric Leach: Not Commercial

Hydrochloric acid has long been of interest in the removal of small amounts of iron where this interfered with the processing of minerals. It has been used for the removal of manganese from tungsten ores. And it's claimed to be a good leaching agent for manganese from low-grade ores.

Some work by the Bureau of Mines, in an attempt to develop a cyclic process for the treatment of low-grade manganese ores, was de-

Pressure Na_2CO_3 Leaching Promising in Uranium

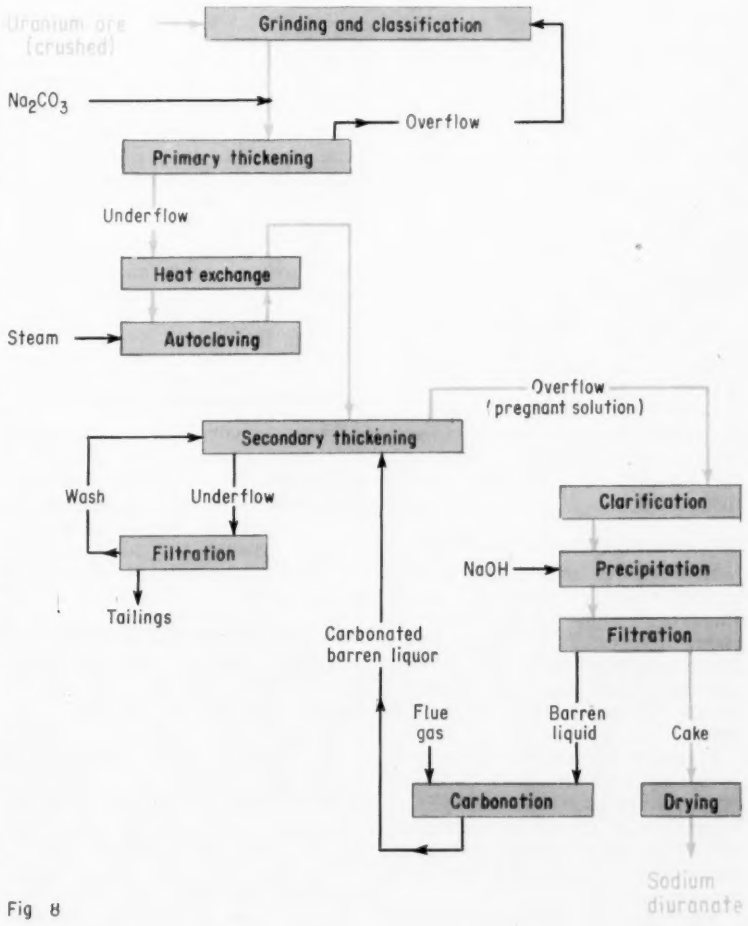


Fig 8

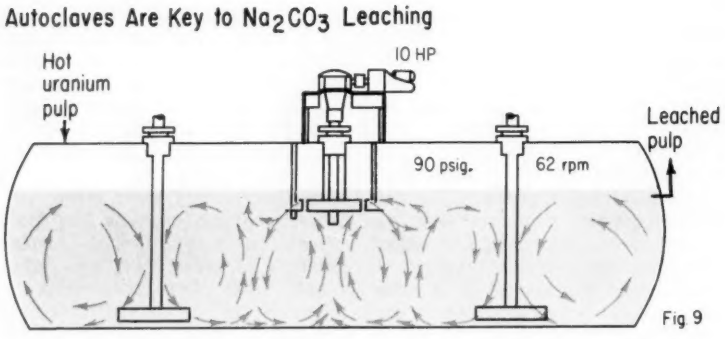


Fig. 9

scribed by Macmillan and Turner.[12]

Ore was roasted in a circulating stream of hydrogen chloride at 950 to 980 C. and the manganese chloride and iron chloride volatalized and collected. Work has not progressed further than the laboratory stage.

A process for the recovery of uranium based on the use of hydrogen chloride and an organic solvent was recently developed by Battelle Memorial Institute.[13]

Finely divided ore is pugged with hydrochloric and sulfuric acids, then leached with acetone. Dissolved uranium precipitates along with iron, vanadium and calcium hydroxides, from the acetone solution by gassing with anhydrous ammonia. Solvent can be used in the treatment of more ore.

Among the advantages claimed for the process: it uses very little water and is applicable in isolated regions where water is unavailable. Disadvantages: both hydrochloric and sulphuric acids are used, corrosion problems may be severe, and the product contains only 10 to 15% U_3O_8.

Hydrofluoric Leach: for Rare Earths

Hydrofluoric acid is a valuable reagent for removing small amounts of silica during the processing of ores. It is becoming increasingly interesting in processing some of the less common metals, including rare earth elements.

Fluorides of many of the metals do not hydrate or absorb moisture in the same way as other halides. There is less danger of contamination by oxygen if a small amount of water is present during the purification process.

Fluorides of most metals are easily reduced by calcium with a formation of calcium fluoride slag which protects the metal from oxidation. Magnesium is also a good reductant for the fluorides. For example, reduction of uranium fluoride by magnesium is one of the standard methods of preparing the metal.

Relatively high cost of fluorine and hydrogen fluoride, as compared to the corresponding cost of chlorine and hydrogen chloride, has been one of the deterents in the progress of fluoride chemistry. Difficulty and danger associated with handling fluorine and hydrogen fluoride has been a second important factor.

Current interest of some of the less known elements and the suitability of the fluoride step for purification probably will increase activity in this field.

Alkaline Leaching Pays Off

The two commonest salts used for leaching are sodium carbonate and ammonium carbonate. Systems using these two reagents are sometimes referred to as alkaline leaches because the pH's of the solutions are somewhat above the neutral point.

Soda Ash Effective for Uranium

Sodium carbonate has been used for a number of years in the leaching of scheelite, a calcium tungstate ore. This process is much more effective when carried out under pressures of up to 100 psi. A small plant processing scheelite operates just out of Salt Lake City by the Salt Lake Tungsten Co.

The carbonate leaching of uranium was developed for ores containing high percentages of calcium carbonate. Ores containing more than 10% calcium carbonate are considered to be more economically processed by sodium carbonate leaching than by an acid treatment. This is because sodium carbonate does not react with calcium carbonate. In acid leaching, calcium carbonate in the ore reacts with sulfuric acid to form calcium sulfate, carbon dioxide and water. Each pound of calcium carbonate consumes a pound of 98% H_2SO_4, which is completely lost for leaching.

A ton of ore with 10% sodium carbonate requires 200 lb. of 98% H_2SO_4. If more than 200 lb. of acid is consumed, cost of sulfuric acid leaching exceeds that of sodium carbonate leaching.

Plant Yields Are High with Pressure

In practice, crushed ore is ground in sodium carbonate solution, then thickened to a 50% solids pulp. This is pumped into autoclaves operating at 70 to 100 psi. and at 220 to 255 F.

Lower oxides of uranium occurring in the ore must be oxidized before they can go into solution as uranyl carbonate. This oxidation is carried out with oxygen dissolved in the solution from air blown through it.

Residence time of the pulp in the circuit is 6 to 15 hr. Temperature is maintained in the autoclaves by the use of steam coils or heat exchangers. Autoclave discharge cools by passing through heat exchangers where it heats incoming pulp. It then passes to a solids-liquid separation system of thickeners in which solids are washed for removal of uranium values. Underflow pulp is filtered, repulped and refiltered to remove as much uranium as possible from the residue.

Pregnant solution, containing most of the uranium values, overflows from the first thickener. This solution, made alkaline with sodium hydroxide, precipitates uranium as sodium uranate. Sodium uranate is filtered on filter presses and the filter cake dried for shipment.

Filtrate from the uranium recovery step contains excess caustic and would be unsuitable for use in the leaching circuit. It may be carbonated by passing through packed towers countercurrent to boiler flue gases or by a submerged combustion oil burner operating in a tank.

Carbon dioxide dissolves, to lower the pH of the solution from about 10 to as low as 7, indicating a conversion of much of the carbonate to bicarbonate.

Sodium carbonate leach is employed by the Eldorado Mining Co. Ltd. in their Beaverlodge plant in Saskatchewan, Canada.[14] Eldorado's carbonate leaching circuit is shown in Fig. 8.

Is Pressure Really Necessary?

The U. S. Atomic Energy Commission has been very much interested in determining whether or not carbonate leaching of uranium ores can be conducted economically at atmospheric pressure. A pilot plant was installed at Grand Junction, Colo., in 1955, including both autoclaves and Pachucas in the circuit. Conclusions, on the basis of short-time operation, were given in a paper at the New Orleans meeting of the AIME, Feb., 1957.[15]

Data indicate an advantage to the use of pressurized leaching from an operational cost standpoint. The main differences seems to be in retention time and in conservation of heat in pressurized vessels. Retention time can be shortened in autoclave operation because the higher pressure permits the water solutions to be held at higher temperatures.

The well-known kinetic approximation of doubling the reaction rate for every 10 C. rise in temperature seems to apply to uranium leaching. Better conservation of heat in the autoclave is a direct application of the laws of physical chemistry to mixed gas-liquid systems.

Use of pressure probably will become more important in future design of leaching systems requiring oxidation and heat. Leaching towers, operated under pressure without the use of internal mechanical agitators, will eliminate most of the operating costs asociated with autoclaves (agitator power cost and high maintenance on pressure seals).[16]

Ammonium Carbonate for Nickel

Ammonium carbonate leaching of uranium ores has been developed to the pilot-plant stage at the Battelle Memorial Institute.[17]

Perhaps a better known use of ammonium carbonate leaching is in recovery of nickel from Cuban laterite ores.

Finely ground ore is given a reduction roast in Herreshof hearth furnaces to reduce nickel to metal. Calcine is leached with ammonium carbonate to dissolve out nickel. The nickel then precipitates as nickel carbonate by boiling to decrease ammonia concentration. Carbonate calcining produces nickel oxide. A description of the operation[18, 19] and chemistry[20] is available.

Caustic Leaches Under Development

Caustic leaching or treatment of an ore with sodium hydroxide is often used where a rather severe attack on the ore is required and where a sodium salt is not objectionable.

Sodium hydroxide can be used in the recovery of thorium and rare earths from monazite sand. Monazite is composed primarily of rare earth phosphates and, depending on its source, may assay: 3 to 10% ThO_2, 0.17 to 0.47% U_3O_8, 40 to 60% $(Re)_2O_3$, 27% Ce_2O_3 and 20 to 30% P_2O_5.

Finely ground monazite reacts with a 50% sodium hydroxide solution by digestion for three hr. at 280 F. After digestion, solution is diluted with water and filtered to separate hydrous oxides from trisodium phosphate. Oxide cake then dissolves in hydrochloric acid. On addition of NaOH, to a pH of 5.8, thorium and uranium precipitate and can be filtered, washed and dried to a product containing 0.74% U, 36.4% Th and 7.45% rare earths.

Further addition of NaOH, after removal of the uranium and thorium, causes precipitation of the rare earths. These can be filtered and dried to give a cake containing 73% rare earths.[21]

New Leach Approach in Sill Process

High arsenic and sulfur impurities present difficult problems in ore processing. Ore roasting can produce polluting off-gases. One solution to this is the acid or alkaline pressure leach discussed previously. However, Harley Sill, a metallurgical engineer, has developed a new approach for cobalt recovery now under pilot-plant development by Metallurgical Resources, Inc., Newburg, N. Y.[22] Instead of solubilizing desired metals, Sill puts arsenates and sulfur into solution, and enriches the ore residue. He uses a NaOH leach.

One of the advantages to the process is arsenate and sulfur can be recovered as calcium arsenate and sodium sulfate for sale.

Technique for the Future: Direct Reduction of Iron Ore With H-Iron Process

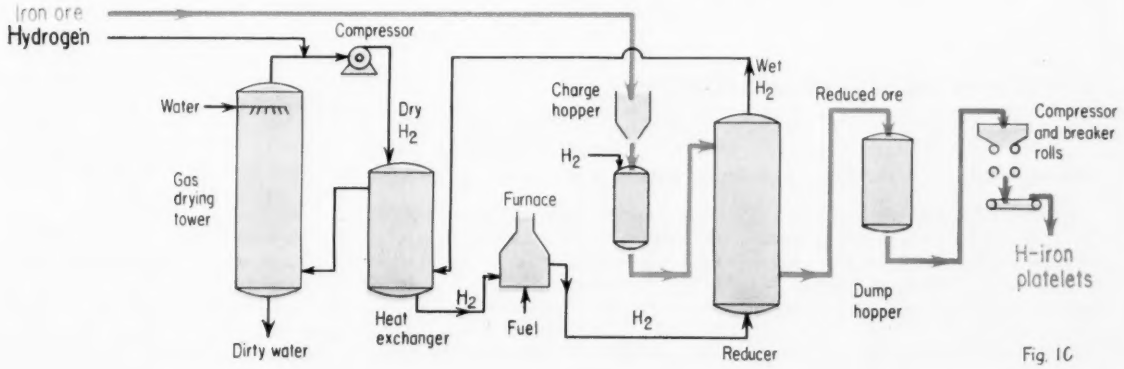


Fig. 10

Salt Roast Wins Vanadium From Uranium Ore

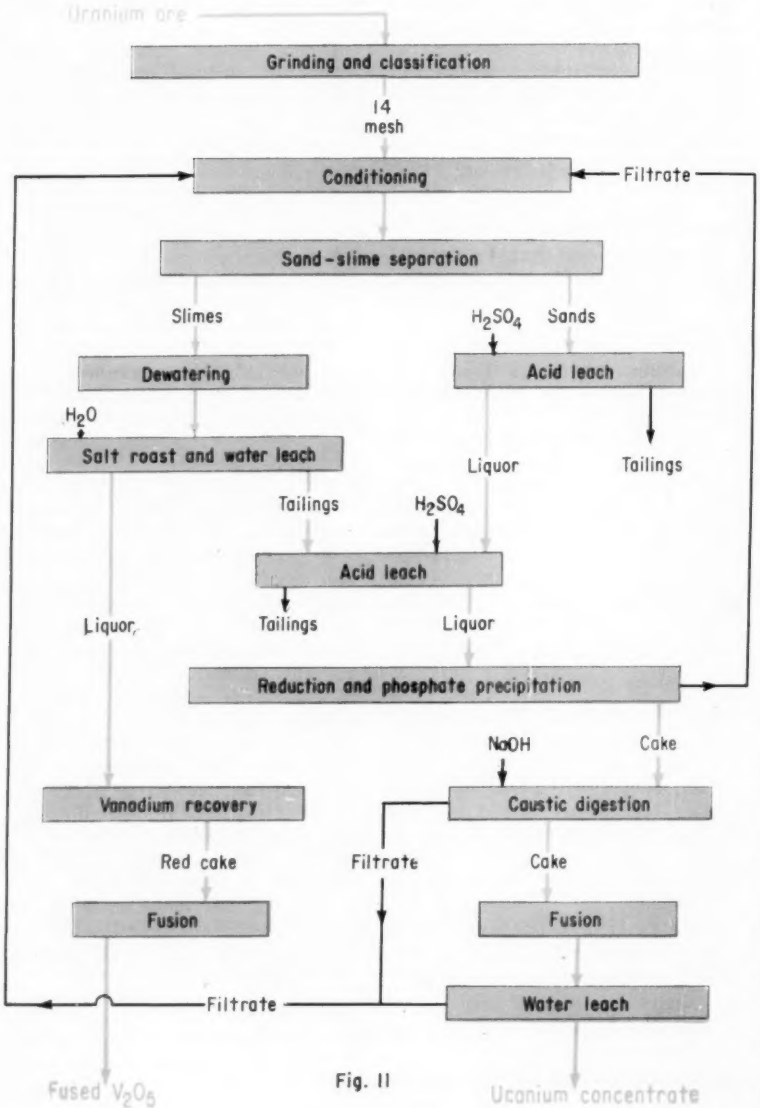


Fig. 11

Advances in Pyrometallurgy

Direct reduction of iron ore, new thermite smelting techniques, and chlorination, highlight high-temperature processes.

Pyrometallurgical techniques differ from hydrometallurgical methods in one important respect: pyrometallurgical changes occur at higher temperatures and usually more rapidly.

High temperatures are expensive, so in practice most of these changes are carried out at the lowest practical temperature. Also in pyrometallurgy, remember too high a temperature may produce fusion of calcines or growth of large grains less soluble in subsequent leaching.

Roasting Widely Used

A roasting operation usually implies reaction between solid material and surrounding atmosphere. The fluidized bed, introduced about 10 yr. ago, has made possible accurate control of roasting temperatures and atmospheres.

Better gas-solids contact is possible in the fluidized-bed roaster because gases flow through the bed of material and keep it in suspension. Uniform temperatures can be maintained throughout the bed and the temperature can be measured with considerable accuracy by inserting a thermocouple into the bed. This is not true of the hearth-type furnace. Here most of the reaction occurs as the material drops from one hearth to the other or through the interface between the gas stream and the mass of material lying on the hearth.

Sulphate roasting has already been discussed under sulphate leaching. The recent rise in the price of sulphur has increased interest in roasting of sulphide material to obtain sulphur dioxide for direct use in processes, for the manufacture of sulphuric acid and still more recently for the direct production of sulphur.

There are at least 8 or 10, 18 to 20 ft. diam. fluidized-bed roasters operating on pyrite to produce sulphur dioxide.

A reactor at Arvida operated by the Aluminum Company of Canada[28a] roasts zinc sulphide to produce sulphur dioxide for the manufacture of sulphuric acid. Four large reactors at Yearington, Nev., operated by the Anaconda Copper Co., burn low-grade sulphur ore to form sulphur dioxide used in the manufacture of sulphuric acid.[28b]

Reduction roasting to produce metallic products is becoming increasingly important. As previously pointed out, nickel in Cuban laterite ore is reduced to metal before leaching in the Nicaro process. More recently importance of the various hydrogen reduction processes has been stressed. Fluidized beds are generally favored for hydrogen reduction of iron ore because of the more uniform product.

Metallurgist Dream: H_2 Reduction

There are a number of economic reasons for the high interest in iron production with direct hydrogen reduction. Three important ones are the rising cost of iron

scrap (necessary for blast furnace operation), increasing use of lower grade ores requiring economic enrichment methods, and the rising cost of new blast furnaces.

Many direct reduction processes for iron are under development in this country. The main ones (pilot plants) are: the R-N process of Republic Steel and National Lead; the H-Iron process of Hydrocarbon Research and Bethlehem Steel; the Nu-Iron process of U. S. Steel; the Esso Research-Little process of Esso Research and A. D. Little.

How H-Iron Process Works

Just as an example, the H-Iron process depends on production of low-cost hydrogen from natural gas or crude oil via the Texaco partial oxidation process (Fig. 10).

Iron ore fines (20 to 325 mesh) feed to a rotary dryer which heats ore to 900 F. Hot ore goes to the reducing vessels. Here it contacts 1,000 F. dry hydrogen at 400 psig. A modified fluid bed is maintained in the vessel as hydrogen passes slowly through the charge. Reduction is a batch operation taking about 8 hr. The fluid bed permits close temperature control in the charge, and intimate contact between ore and gas.[34, 35]

Reduced iron is pyrophoric and must be agglomerated by hot compression rolls to metal powder plates which are broken into platelets.

Off-gas, under pressure, is cooled to 100 F. to remove water vapor. Makeup hydrogen is added, the hydrogen recompressed, reheated and returned to the reducing vessel.

This batch process operates at relatively low temperatures because reduced iron has a tendency to stick together at high temperatures. Complete reduction to metallic iron has not been practical above 1,500 F. Defluidization often occurs at 1,100 F.

At low temperatures, equilibrium is unfavorable, so the H-Iron process uses high pressures to offset this.

Much Interest in Swedish Process

The Wiberg-Soderfors process for direct reduction of iron ore has developed to a production stage in Sweden and is creating considerable interest in the U. S.[36]

Reducing gas is a mixture of carbon monoxide and hydrogen. After passing through a shaft furnace, where it reduces lump or pelleted iron ore, the gas mixture contains considerable carbon dioxide. This is converted to CO by passing through an electrically heated coke-filled carburetor and recycled. Iron is about 90% reduced to sponge metal and contains 0.9% carbon, 0.01% phosphorus and 0.01% sulfur. This is melted in arc furnaces.

Another recent Swedish process is directly related to Wiberg-Soderfors. This is the Stora Powder Steel process, developed by Stora Kopparberg.[37]

Starting material now is granulated pig iron, but could be high-grade sponge iron. In the process, a 85% iron, 15% high-purity iron ore concentrate is packed into a sheet steel box and covered by welding on a sheet steel top. It is then decarburized at 2,000 F. and rolled at 2,000 to 2,200 F. to produce steel having properties similar to electric-furnace steel.

Costs are $10 to $20 per ton less than by conventional methods.

One day we might see reduction of suitable iron ore concentrates by the H-Iron or Soderfors process and production of steel by direct rolling of the sponge, without a blast furnace or open hearth.

Most steel men will agree, however, that the blast furnace is a fairly economical piece of equipment to compete against in highly industrialized areas. Perhaps direct reduction and rolling will find first use in less developed areas, or those having good iron ore and fuel re-

Smelting Produces Titanium Concentrate From Iron Ore

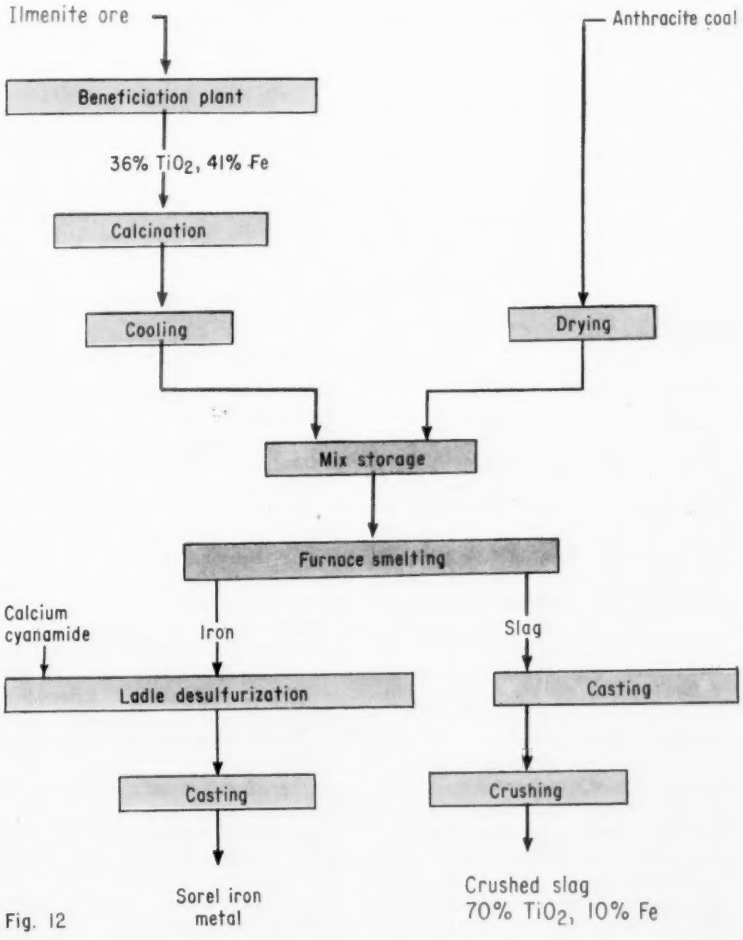


Fig. 12

Fluidized Chlorination: Key to Pure $TiCl_4$

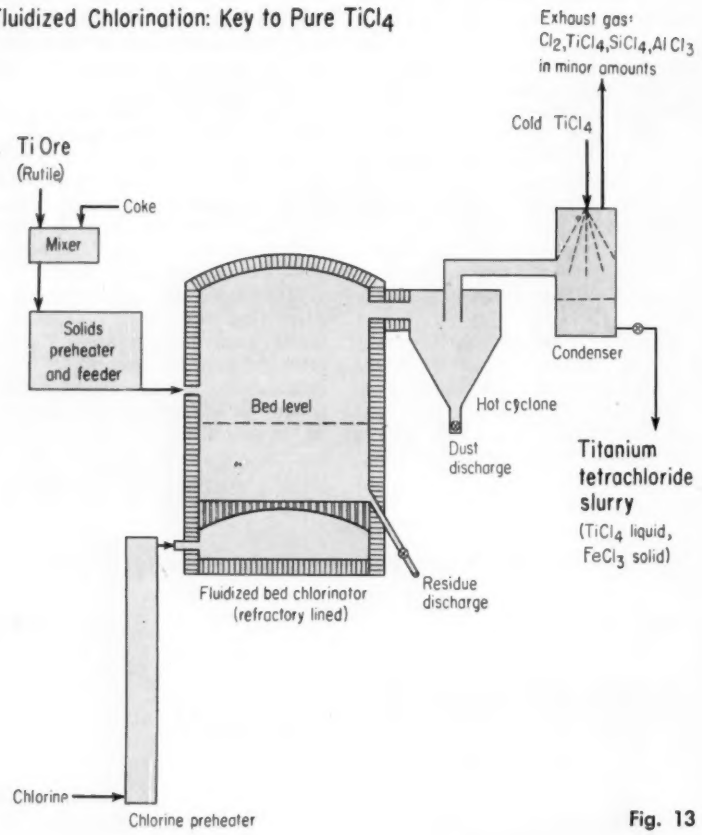


Fig. 13

serves, but lacking coking coal necessary for blast furnace operation.

Salt Roasting Gets Vanadium

Salt roasting or roasting of a mixture of ore and sodium chloride is quite old in extractive metallurgy. It has been used for the conversion of lead molybdate and lead tungstate ores to lead chloride and sodium molybdate or sodium tungstate. It is also used in recovering vanadium from certain uranium ores.

Lennemann[18] gives flowsheets for both acid and alkaline circuits for vanadium and uranium recovery following a salt roast. The flowsheet of the Climax Uranium Co. is shown in Fig. 11.

A sand-slime separation is made before the salt roast because most of the vanadium occurs on the slimes. These are dried, given a salt roast at 835 C. and water leached to dissolve vanadium. After filtering to remove gangue, vanadium precipitates as sodium metavandate by adding some H_2SO_4.

Smelting: Opens Sources

The term smelting is applied to the formation of liquid metals and slags and usually includes gravity separation of the liquid metal.

Smelting of ores is probably one of the oldest methods of extractive metallurgy. Its use in the production of iron and steel, in copper production and in the production of ferroalloys, phosphorus and ferrophosphorus, are well known and have changed little in the past few years. A few adaptations of this melting technique have opened up new sources of raw materials which were otherwise too low grade to be of interest.

One of the most interesting of these, possibly because of the current interest in the metal involved, is the smelting of ilmenite in electric furnaces to produce pig iron and a slag with a high titanium oxide content. Preliminary work on smelting of ilmenite was carried out by the Bureau of Mines in the 1940's.

Titanium From Sorel Ore

After the Allard Lake ilmenite deposite was discovered in Quebec, Canada, the slag smelting process was piloted by the New Jersey Zinc Co. Eventually a plant was built at Sorel for treatment of Allard Lake ore. Fig. 12 is a flowsheet of the Sorel plant[20] modified on the basis of information given by Trottier.[20]

Ore is crushed and concentrated by gravity to remove as much gangue material as practical. Final concentrate contains approximately 36% TiO_2 and 41% Fe. It mixes with anthracite coal and is smelted in electric arc furnaces to produce a slag containing approximately 70% TiO_2 and 10% iron. The pig iron is of acceptable quality and finds a ready market in the steel industry.

New Developments in Titanium

The Bureau of Mines at Albany, Ore., and the Japanese, have continued their work on smelting of ilmenite with the production of higher and higher TiO_2 content slags. They are reported to have produced slags assaying more than 95% TiO_2, if all the titanium contained is calculated to the TiO_2 basis.[21]

Udy Process Makes Ferromanganese

Another new smelting process is one developed for making ferromanganese from low-grade ores. This is the Udy process which is in operation in a prototype plant at Niagara Falls.[22]

A new furnace design involves a short arc, careful feeding of ore, close temperature control and low fume losses. Stepped sides in the furnace direct feed into the slag and avoid agglomeration.

The process requires three furnaces. In the first molten ore is smelted at 1,350 C. with lime and coal. A controlled amount of iron and impurities is removed here. All the manganese remains in the slag.

The Mn-rich slag goes to the second furnace, reacts with reducing agents to produce either high-carbon ferromanganese or ferromanganese silicon. This can be used as the reducing agent in a third furnace to convert first furnace Mn-rich slag to low or medium carbon ferromanganese.

This process appears to work well on low-grade ores, and costs are very promising.

Thermite Smelting: Special

Thermite has usually been considered a laboratory curiosity, capable of providing a brilliant display for visitors. Recent advances in technique, purity of reacting materials, and refractories, allow thermite smelting to fill an important place in producing special alloys and metals.

Advantages of thermite smelting are (1) freedom from contamination of the melt by electrodes, (2) complete fusion of the alloy product, (3) almost instantaneous melting so refractory problems are minimized.

It has been used for the production of a number of ferroalloys including ferrotungsten, ferromolybdenum, and ferrovanadium. More recently it is being adapted to the production of a number of alloys which are finding use in the nonferrous field.

The basic process involves reduction of an oxide or oxides of the desired metals by reaction with aluminum. External heat is not required. Reaction between metallic aluminum and metal oxide supplies sufficient heat for the smelting operation.

This concept has broadened to include reduction with other elements such as silicon, magnesium, calcium, sodium, and other reactive metals. Compounds to be reduced now include chlorides and fluorides as well as oxides.

The process is carried out quite simply. Finely ground material is mixed thoroughly with a ground reducing agent. Fluxing agents, such as powdered fluorspar, are sometimes added. Mixture is placed in a refractory crucible capable of withstanding the thermal shock of going from room temperature to as high as 4,000 F. in a few seconds. An ignition mixture consisting of barium or sodium peroxide and some of the reducing agent is placed in the center of the charge and ignited by a fuse. Reaction spreads rapidly from point of ignition until the entire charge reacts.

Reaction is exothermic and, under favorable conditions, produces sufficient heat to melt the metal or alloy produced and the oxide of the reducing agent (which usually acts as a covering slag for the metal or alloy). Usually a thin slag layer, or a layer of fused refractory, surrounds the liquid metal and protects it from oxidation. Fluxing agents added to the mixture produce a more fluid slag.

Metal collects as a liquid pool in the bottom of the reaction chamber, covered by liquid slag. The products are allowed to solidify and cool.

Metal or alloy usually is separated as a solid ingot or "button" form.

Thermite reactions are usually run in batches. Commercial heats containing up to 5,000 lb. of reacting materials and producing metal buttons weighing a ton or more are common.

Peroxides Boost Temperatures

Until recently, one of the limitations on thermite processes was the amount of heat supplied by the reaction between metallic compound and reducing metal. This had to be sufficient for fusion of the metal and slag or the reaction did not produce clean separations. This limitation has been overcome, to some extent, by the use of compounds such as sodium peroxide or barium peroxide. These supply oxygen for reaction with an excess of reducing agent and produce additional heat, increasing the temperature at which total reaction takes place.

A recent patent[23] covers use of liquid oxygen in the thermite mixture.

Final reduction of uranium fluoride by magnesium can be considered a thermite process. This is ordinarily carried out in an inert atmosphere to protect the metal from oxidation.

Volatilization: High Purity

A number of chemical compounds of the metals have high vapor pressures at temperatures attainable in commercial furnaces. These vapor pressures are substantially above those of the gangue materials, so compounds containing the metal may be purified by evaporation.

Vaporization is applicable also to the purification of a number of the metals themselves. For example, the purest zinc, sodium, magnesium, and calcium, are purified by distillation. A good example of a compound that can be purified by sublimation is molybdic oxide which sublimes at temperatures above 1,300 F. A molybdic oxide of 99.95% purity can be produced by sublimation.

Sometimes the elimination of an impurity, rather than purification of the volatile material, is the objective of a volatilization process. For example, arsenic and antimony are cyanide consumers in the cyanide leaching of gold. The lower oxides are volatile and can be driven off in a sulphur dioxide atmosphere. If air is present, they oxidize to As_2O_5 and Sb_2O_5. These are not volatile and remain in the residue.

Gold ore, produced at the Giant Yellowknife Mine on the Great Slave Lake in Canada, contains high percentages of arsenic and considerable antimony. A two compartment fluidized-bed reactor is used for elimination of arsenic and antimony by the simple expedient of running the first compartment with a deficiency of air. Sulphur in the ore burns to sulphur dioxide, while antimony and arsenic burn and vaporize into the gas stream.

Calcines then pass into the second compartment of the reactor, where an excess of air is used to burn out remaining sulphur.

Dust collects in hot cyclones through which arsenic and antimony pass as vapors. Gases then cool and condensed arsenic and antimony fumes collect in a Cottrell percipitator.

A unique sidelight on this operation is the disposal method for arsenic trioxide. This has always been a problem because the oxide is poisonous and quite soluble. It cannot be left out to be dissolved in surface water. The Giant Yellowknife Mine is located in the "perma frost" region where underground temperatures never rises above the freezing point. Arsenic trioxide is reportedly stored in underground rooms where it will remain forever frozen and will not be carried into the underground water supply.

Chlorination: Way to Ti,Zn

Chlorides of a number of metals are volatile. This fact forms the basis for a number of processes to recover metals from their ores.

The Bureau of Mines published some work about 1940 indicating that use of chlorine would be an interesting method of recovering metals from ore. Ore was treated

with chlorine at atmospheric pressure in a heated vessel and volatile chlorides driven off. Since that time, chlorination of metal oxides has developed rapidly.

The now well known Kroll process for the production of titanium and zirconium required pure chlorides. Chlorination techniques were developed and improved to supply this purified material.

Some oxides may be chlorinated directly because the reaction between chlorine gas and oxide is exothermic. Metal chloride and oxygen are products of such a reaction. If carbon is present in the reaction zone to accept oxygen liberated from the metal, the free energy of the reaction increases so exothermic reactions are obtained with a wider variety of substances. A paper on chlorine chemistry by Kellogg[34] discusses the thermodynamics involved.

Chlorination Has Wide Applications

In the first published process for the chlorination of titanium dioxide, a mixture of rutile and carbon was briquetted and chlorinated directly. Now a fluidized-bed chlorinator has been developed for carrying out the chlorination reaction (Fig. 13). The fluidized bed has the advantage of maintaining a uniform temperature throughout the reaction zones—build-up of less volatile chlorides in the reactor is avoided.

Present interest in chlorination is concentrated on titanium and zirconium chlorides. The process is also applicable to the production of the chlorides of many other reactive elements such as tungsten, molybdenum, vanadium, columbium, and silicon.

After purification, chlorides may be reduced by reaction with sodium or magnesium to produce pure metals free from oxygen and nitrogen. Chlorides are usually distilled from the ore rather than leached out with water. This is necessary because chlorides of the more reactive metals are hydrolized in the presence of water to form insoluble oxides.

Chlorination of most ores produces mixtures of chlorides. It's necessary to make separations of desired chloride from the contaminating ones. Separation can usually be carried out by distillation because of difference in vapor pressures of the chlorides. A mixture of vanadium oxychloride and titanium tetrachloride is a notable exception, distillation not being effective in removing all the $VOCl_3$.

A number of patents have been issued covering separation of vanadium chloride from titanium tetrachloride. The suggested methods include use of hydrogen sulphide, certain organic reagents, copper or other metal powders, or a trace of water. All of these, except water, act as reducing agents for the vanadium oxychloride. Water hydrolizes vanadium oxychloride preferentially, along with some titanium chloride. Reduced or hydrolized products precipitate out of the titanium tetrachloride and remain as a sludge in the bottom of the distillation column.

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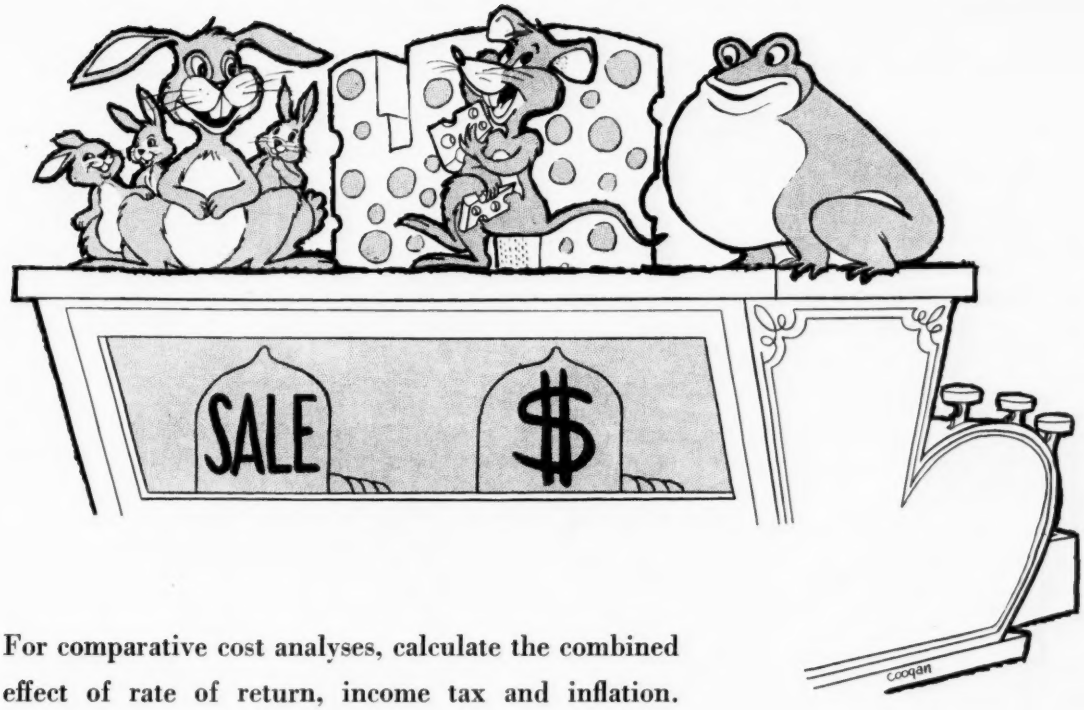

For comparative cost analyses, calculate the combined effect of rate of return, income tax and inflation.

Remember All Three in Cost Analyses

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Wherever money is spent, you'll find those three strange animals at work—return on investment, income tax and inflation. If your work involves costs or how money is spent, don't ever forget you'll have to tangle with these vital forces.

In running a complete cost analysis, the role a company plays with these elements clears up a bit. Companies can't exist without the investors who start and maintain it. They're considered by including a return on investment. Supporting the government comes high. Companies assume this obligation to help through income taxes. And then there's the problem of the decaying dollar, so the effect of inflation is also accounted for.

In earlier articles we made cost comparisons based on capitalized costs using return on investment alone,[1] return on investment and inflation,[2, 3] and return on investment and income tax.[4]

Now, in this article we'll show how all three—return on investment, income tax and inflation—can be considered together.

What Is Capitalized Cost?

Capitalized cost is used to designate the first cost plus the present value of an indefinite number of renewals. It's the cost on a perpetual basis, or the cost if the article or process were in use forever.

However, we don't mean to imply that an item will be replaced in kind forever. We use "forever" merely as a common denominator to compare all service lives on the same basis.

In engineering problems, practically all costs fall into five categories. They are: initial cost, uniform annual expense, irregular yearly expense, salvage value and nondepreciable expense.

We'll discuss these in order. Our equations will be expressed in terms of r, the return on investment after taxes, t the income tax rate and d the inflation rate, all expressed as decimals.

Any values for r, t and d can be used with the equations but for the purposes of illustration most of the numerical examples have $r = 8\%$, $t = 52\%$ and $d = 4\%$. Any depreciation method for income tax purposes can also be accommodated, but the sum-of-the-digits method is used in the numerical examples.

Income tax will be treated as if it were paid in full at the end of the year. Salvage value, in the same way, refers to the end of the year. All other costs refer to the beginning of the year.

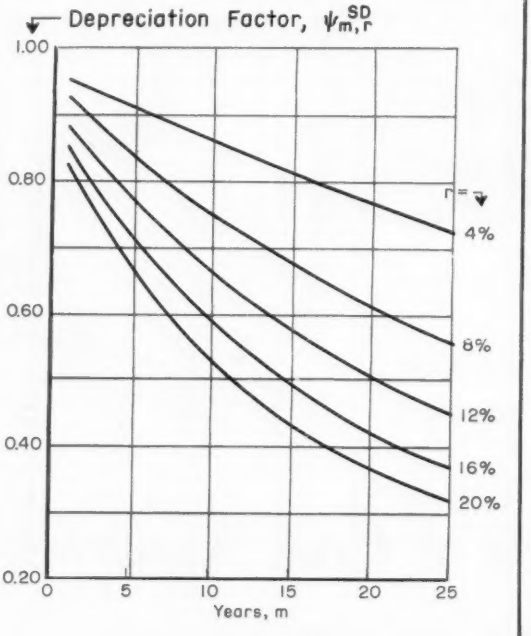
Start With the Initial Cost

Suppose an article lasts m years and we let the symbol C_d stand for the depreciable part of the first

* Meet your author on page 167.

Use These Factors to Solve the Equations

m	$I_{m,4\%}$	$I_{m,8\%}$	$\psi_{m,8\%}^{SD}$	$(1-0.52\psi_{m,8\%}^{SD})$	$\left(\frac{I_{m,8\%}}{I_{m,8\%}-I_{m,4\%}}\right)$
1	1.0400	1.0800	0.9259	0.5185	27.00
2	1.0816	1.1664	0.9035	0.5302	13.75
3	1.1249	1.2597	0.8817	0.5415	9.342
4	1.1699	1.3605	0.8598	0.5529	7.138
5	1.2167	1.4693	0.8397	0.5634	5.817
10	1.4802	2.1589	0.7477	0.6112	3.181



cost. This then, is the first cost minus the salvage value. Later we'll show how to include salvage value. Present value of C_d therefore, is simply C_d.

Present value of its tax credits (these are negative since they are a reduction in tax and therefore income) are:

$$-tC_d\sum_{x=1}^{x=m}\frac{D_x}{(1+r)^x}$$

where D_x is the depreciation, expressed as a fraction, for the x-th year.

Present value of the depreciable part of the first cost and its tax credits is the sum of the two and is:

$$C_d - tC_d\sum_{x=1}^{x=m}\frac{D_x}{(1+r)^x} \qquad (1)$$

Depending upon the depreciation method used the summation part of Eq. (1) varies, but the equation still reduces to the form:

$$C_d\,(1-t\psi_{m,\,r}) \qquad (2)$$

where

$$\psi_{m,r}=\sum_{x=1}^{x=m}\frac{D_x}{(1+r)^x} \qquad (3)$$

At the end of m years, the article will be replaced by another. Because of inflation all costs will have increased by a factor of $(1+d)^m$. Corresponding to Eq. (1) the present value of the depreciable cost for this article is:

$$\left[\frac{C_d\,(1+d)^m}{(1+r)^m}\right]-\left[\frac{tC_d\,(1+d)^m}{(1+r)^m}\right]\sum_{x=1}^{x=m}\frac{D_x}{(1+r)^x}$$

This, by virtue of Eq. (3), becomes:

$$C_d\,[1-t\psi_{m,r}]\,[(1+d)^m/(1+r)^m]$$

Similarly, the present value of the depreciable cost of the next replacement is:

$$C_d\,(1-t\psi_{m,r})\,[(1+d)^{2m}/(1+r)^{2m}]$$

If we take the present value and extend it to an indefinite number of replacements we have the capitalized cost $K_{i,\,d}$

$$K_{i,d}=C_d\,(1-t\psi_{m,r})\sum_{a=0}^{a=\infty}\frac{(1+d)^{am}}{(1+r)^{am}}$$

that reduces to:

$$K_{i,d}=C_d\,(1-t\psi_{m,r})\left(\frac{I_{m,r}}{I_{m,r}-I_{m,d}}\right) \qquad (4)$$

where $r>d$

$$I_{m,r}=(1+r)^m$$
$$I_{m,d}=(1+d)^m$$

Considering all the conditions that it fulfills, Eq. (4), the desired relationship, is remarkably compact.

As it stands, this equation is exact only if $r>d$, but later we'll show how to remove this limitation. Calculation of the ψ factor is done by Eq. (3) and the value depends upon the depreciation method used. For illustration in this article, sum-of-the-digits depreciation is used for which the ψ factor is designated $\psi_{m,\,r}^{SD}$ and is plotted in the accompanying figure.

For convenience in checking the numerical examples we've shown selected values of various factors.

Problem 1—A tank costs \$10,000 and lasts 2 years. Money is worth 8%/year after taxes, the income tax rate is 52% and the inflation rate is 4%/year.

How much can we spend for a tank that lasts 5 years?

Solution—By Eq. (4), capitalized cost for the 2-year tank is:

$$K_{i,d}=(10{,}000)\,(1-0.52\psi_{2,8\%})\left(\frac{I_{2,8\%}}{I_{2,8\%}-I_{2,4\%}}\right)$$
$$=(10{,}000)\,(0.5302)\,(13.75)$$
$$=72{,}000.$$

For the 5-year tank with the same capitalized cost:

$$72{,}900=C_d\,(1-0.52\psi_{5,8\%})\left(\frac{I_{5,8\%}}{I_{5,8\%}-I_{5,4\%}}\right)$$
$$72{,}900=C_d\,(0.5634)\,(5.817)$$
$$C_d=\$22{,}240.$$

That is, up to \$22,240 can be spent for the 5-year tank.

Then the Uniform Annual Expenses

If M is a uniform annual expense—uniform except for the effect of inflation—the capitalized cost is obtained by placing $m = 1$ in. Eq. (4):

$$K_{t,d} = M\,(1 - t\psi_{1,r})\left(\frac{1+r}{r-d}\right) \qquad (5)$$

where $r > d$

$$\psi_{1,r} = 1/(1+r)$$

Numerically, M is the first year expense. This expense will increase by a factor of $(1 + d)$ each year, but it's allowed for in the equation. Also, Eq. (5) assumes that M will be written off in full at the end of the year for tax purposes.

Problem 2—A tank costs \$10,000 and lasts 2 years. Money is worth 8%/year after taxes, the income tax rate is 52% and the inflation rate is 4%/year.

How much can we spend for lining the tank at the beginning of every year so as to get a 5-year life?

Solution—Capitalized cost of the 2-year tank was calculated in Problem 1 and is \$72,900. We'll depreciate the lined tank over a 5-year life.

Capitalized cost of the lined tank must not exceed \$72,900 and is obtained by combining Eqs. (4) and (5).

$$72{,}900 = (10{,}000)\,(1 - 0.52\psi_{5,8\%})\left(\frac{I_{5,8\%}}{I_{5,8\%} - I_{5,4\%}}\right) + M\,(1 - 0.52\psi_{1,8\%})\left(\frac{1+r}{r-d}\right)$$

$$72{,}900 = (10{,}000)\,(0.5634)\,(5.817) + M\,(0.5185)\,(27.00)$$

$$M = \$2{,}866.$$

That is, up to \$2,866 can be spent at the beginning of the first year with the understanding that the cost will rise 4%/year.

What About Irregular Yearly Expenses?

You can use Eq. (5) only if the yearly expense, except for the effect of inflation, is regular. If the yearly expense is irregular a more general equation is needed.

Suppose an expense B_x, in terms of the present dollar, is incurred at the beginning of the x-th year for an article lasting m years. Moreover B_x is written off in full at the end of the x-th year. Then the capitalized cost of the single expense B_x is:

$$K_{t,d} = B_x\,(1 - t\psi_{1,r})\,I_{(x-1),d}\left(\frac{I_{(m-x+1),r}}{I_{m,r} - I_{m,d}}\right) \qquad (6)$$

where $r > d$

$$\psi_{1,r} = 1/(1+r)$$

As mentioned B_x is in terms of the present dollar. This equation allows for the fact that the expense will actually be $B_x\,(1 + d)^{x-1}$ when it is incurred at the beginning of the x-th year. All yearly expenses can be accommodated by Eq. (6), however irregular they may be, by adding over all the years.

Salvage Value is Important

We have mentioned that in Eq. (4) C_d is the depreciable part of the first cost and is equal to the initial cost less the salvage value. Now we've got to consider the nondepreciable part of the first cost—the salvage value L.

Suppose an item costs \$115,000 and would have a salvage value of \$15,000 if inflation wasn't a factor. Of the first cost, the depreciable part is \$100,000 and can be handled by Eq. (4).

However, the \$15,000 salvage value is more complicated. Because of inflation, the actual salvage value may be, say, \$25,000 when it is realized m years from now. At that time there will be a \$10,000 profit, subject to taxes in some way that may vary with the circumstances and the company. We treat this profit as subject to the capital gains tax g that is now 25% for corporations. All the above considerations lead to the relationship:

$$K_{t,d} = L\left(1 + \frac{1}{G_{m,d}} \times \frac{g}{I_{m,r} - I_{m,d}}\right) \qquad (7)$$

where $r > d$

$$G_{m,d} = \frac{1}{[(1+d)^m - 1]}$$

Here L is what the salvage would be worth in today's dollar and g is the capital gains tax expressed as a decimal.

In the Case of Nondepreciable Expenses

Nondepreciable expenses require some consideration of what is meant. The relationship given by Eq. (7) is for a nondepreciable amount that increases in value with inflation and eventually becomes subject to the capital gains tax.

Land on which a plant is built cannot be depreciated unless it can be depleted, such as mining property. Let N denote the present purchase price of land to be used for a venture lasting m years. Assume further that at the end of m years the land won't be sold but will be used for another venture. For this case, Eq. (7) will apply with $g = 0$ and the capitalized cost will be:

$$K_{t,d} = N \qquad r > d \qquad (8)$$

Nomenclature

B_x	Yearly expense, beginning of the x-th year, present dollars.
C_d	Initial cost of facility minus salvage value, dollars.
C_w	Working capital increasing in step with inflation, present dollars.
C_w'	Working capital, fixed, dollars.
d	Inflation rate, decimal/year.
D_x	Depreciation for the x-th year, decimal.
g	Capital gains tax, decimal.
$G_{m,d}$	$1/[(1+d)^m - 1]$
$I_{m,r}$	$(1+r)^m$
$k_{t,d}$	Equivalent yearly burden with taxes, dollars/year.
$K_{t,d}$	Capitalized cost with taxes, dollars.
L	Salvage value, present dollars.
m	Useful life of a facility, years.
m'	Fast write-off time, years.
M	Fixed annual burden, constant except for inflation, present dollars/year.
N	Nondepreciable expense, dollars.
r	Rate of return on investment after taxes, decimal/year.
t	Income tax rate, decimal.
$\psi_{m,r}$	Factor associated with depreciation.

Working capital is another type of expense that can't be depreciated. Working capital is used for more than one purpose, but this discussion is limited to working capital that can be regarded as cash on hand to conduct a venture lasting m years.

If C_w' represents a cash sum put up at the beginning and not increased during the venture then the capitalized cost for putting up C_w' dollars now is obtained from Eq. (4), noting that $\psi_{m,r} = 0$ for a nondepreciable expense. This gives for the capitalized cost:

$$C_w'\left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}}\right) \qquad (9)$$

Also, the capitalized cost for recovering C_w' dollars m years from now is:

$$\left(\frac{-C_w'}{I_{m,r}}\right)\left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}}\right) \qquad (10)$$

where division by $I_{m,r}$ is necessary to convert to the present.

Total capitalized cost is the sum of Eqs. (9) and (10) and is:

$$K_{t,d} = C_w'\left(\frac{I_{m,r} - 1}{I_{m,r} - I_{m,d}}\right) \qquad r>d \quad (11)$$

Differences between Eqs. (8) and (11) arise because N refers to an item that increases in dollar value with inflation while C_w' corresponds to cash.

Because of inflation it might be necessary to increase the working capital each year. For this circumstance the relationship is:

$$K_{t,d} = C_w\left(\frac{r}{r-d}\right) \qquad r>d \quad (12)$$

where C_w increases by the factor $(1 + d)$ each year.

Differences between Eqs. (11) and (12) should be noted. In Eq. (11) a cash sum C_w' is put up at the beginning of the venture without additions. In Eq. (12) additions are made at the beginning of each subsequent year in step with inflation.

The Equivalent Yearly Burden

We may want to express the cost of an article or a system in terms of the yearly cost referred to the end of the year. When inflation is a factor we can't use an equivalent uniform yearly cost. A yearly cost, increasing by the factor $(1 + d)$ each year, has to be used. We'll call this the equivalent end-of-year yearly burden. This can be obtained from the capitalized cost with the simple relationship:

$$k_{t,d} = (r - d)K_{t,d} \qquad r>d \quad (13)$$

where $k_{t,d}$ is the equivalent yearly burden. Its meaning when taxes are considered is apparent from the following example:

Problem 3—An article costs $10,000 and lasts 4 years. Money is worth 8%/year after taxes, income tax is 52% and the inflation rate is 4%/year.

What is the equivalent yearly burden? Show that it will exactly repay the original cost with return on investment.

Solution—Capitalized cost by Eq. (4) is:

$$K_{t,d} = (10{,}000)\,(1 - 0.52\psi_{4,8\%})\left(\frac{I_{4,8\%}}{I_{4,8\%} - I_{4,4\%}}\right)$$
$$= (10{,}000)\,(0.5529)\,(7.138)$$
$$= 39{,}466$$

And by Eq. (13) the equivalent yearly burden is

$$k_{t,d} = (0.08 - 0.04)\,(39{,}466)$$
$$k_{t,d} = \$1{,}579 \rightarrow$$

where the arrow alongside $1,579 emphasizes that it increases by the factor $(1 + d)$ each year.

$1,579 → at the end of each year will amount to $7,523 at the end of the fourth year:

$$(1{,}579)\,(1.04)^0\,(1.08)^3 = \$1{,}989$$
$$(1{,}579)\,(1.04)^1\,(1.08)^2 = 1{,}915$$
$$(1{,}579)\,(1.04)^2\,(1.08)^1 = 1{,}843$$
$$(1{,}579)\,(1.04)^3\,(1.08)^0 = 1{,}776$$
$$\$7{,}523$$

Sum-of-the-digits depreciation has been used. Sum of the digits is $4 + 3 + 2 + 1 = 10$. Depreciation for end of first year is ($10,000) (4/10), second year ($10,000) (3/10), etc. Value of the tax credits from depreciation amounts to $6,082 as of the end of the fourth year:

$$(0.52)\,(4{,}000)\,(1.08)^3 = \$2{,}620$$
$$(0.52)\,(3{,}000)\,(1.08)^2 = 1{,}819$$
$$(0.52)\,(2{,}000)\,(1.08)^1 = 1{,}123$$
$$(0.52)\,(1{,}000)\,(1.08)^0 = 520$$
$$\$6{,}082$$

Total amount available at the end of the fourth year is $13,605:

$$\$7{,}523 + 6{,}082 = \$13{,}605$$

But the $10,000 initial cost is also worth $13,605 at the end of the fourth year:

$$(10{,}000)\,(1.08)^4 = \$13{,}605.$$

When Inflation is Greater Than Rate of Return

Equations given to this point have been limited to the condition that $r>d$. That's because the series that have been added are finite only if $r>d$. For inflation rates where $d>r$ we introduced the concept of extended capitalized cost in an earlier article.[3]

Extended capitalized cost can be used just like a capitalized cost. Where taxes are included the following relationship holds:

$$K_{t,d>r} = -K_{t,d} \qquad (14)$$

This simply means that the extended capitalized cost when $d>r$ is always the negative of the corresponding capitalized cost $K_{t,d}$. When $d>r$, the capitalized cost $K_{t,d}$ becomes negative but the extended capitalized cost is positive.

Extended capitalized costs corresponding to Eqs. (4), (5), (6), (7), (8), (11) and (12) are respectively:

$$K_{t,d} = C_d\,(1 - t\psi_{m,r})\left(\frac{I_{m,r}}{I_{m,d} - I_{m,r}}\right) \qquad d>r \quad (15)$$

$$K_{t,d} = M\,(1 - t\psi_{1,r})\left(\frac{1+r}{d-r}\right) \qquad d>r \quad (16)$$

$$K_{t,d} = B_z\,(1 - t\psi_{1,r})\,I_{(z-1),\,d}\left(\frac{I_{(m-z+1),r}}{I_{m,d} - I_{m,r}}\right) \qquad d>r \quad (17)$$

$$K_{t,d} = L\left(-1 + \frac{1}{G_{m,d}} \times \frac{g}{I_{m,d} - I_{m,r}}\right) \qquad d>r \quad (18)$$

$$K_{t,d} = -N \qquad d>r \quad (19)$$

$$K_{t,d} = C_w' \left(\frac{I_{m,r} - 1}{I_{m,d} - I_{m,r}} \right) \qquad d > r \quad (20)$$

$$K_{t,d} = C_w \left(\frac{r}{d - r} \right) \qquad d > r \quad (21)$$

When $d > r$ the equivalent yearly burden is

$$k_{t,d} = (d - r)\, K_{t,d} \qquad d > r \quad (22)$$

Problem 4—A tank costs \$10,000 and lasts 2 years. Money is worth 8%/year after taxes, income tax is 52% and the inflation rate is 12%/year.

How much can be spent for a tank that lasts 5 years?

Solution—By Eq. (15), the extended capitalized cost for the 2-year tank is:

$$K_{t,d} = (10{,}000)\,(1 - 0.52\psi_{2,8\%}) \left(\frac{I_{2,8\%}}{I_{2,12\%} - I_{2,8\%}} \right)$$

$$I_{2,12\%} = 1.2544$$

$$K_{t,d} = (10{,}000)\,(0.5302)\,(13.25)$$

$$= 70{,}250$$

Using the same extended capitalized cost for the 5-year tank:

$$70{,}250 = C_d\,(1 - 0.52\psi_{5,8\%}) \left(\frac{I_{5,8\%}}{I_{5,12\%} - I_{5,8\%}} \right)$$

$$I_{5,12\%} = 1.7623$$

$$70{,}250 = C_d\,(0.5634)\,(5.015)$$

$$C_d = \$24{,}860$$

that is, up to \$24,860 can be spent for the 5-year tank.

Consolidation of Inflation Rates

It's possible to consolidate the equations for real and extended capitalized costs into a single equation. For the depreciable cost C_d of an article lasting m years:

$$K_{t,d} = C_d\,(1 - t\psi_{m,r}) \left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}} \right) \qquad r > d$$

$$K_{t,d} = C_d\,(1 - t\psi_{m,r}) \left(\frac{I_{m,r}}{I_{m,d} - I_{m,r}} \right) \qquad d > r$$

Both can be expressed as a single equation:

$$K_{t,d} = C_d\,(1 - t\psi_{m,r}) \left(\frac{I_{m,r}}{|I_{m,r} - I_{m,d}|} \right) \qquad d \neq r \quad (23)$$

where the vertical bars mean a positive value must be used for the factor between these bars. For any value of d other than $d = r$, Eq. (23) can be used.

Notation similar to that used in Eq. (23) can be set down for other types of costs. As an example, Eqs. (8) and (19) can be combined if they are written as:

$$K_{t,d} = N\,(I_{m,r} - I_{m,d}) \left(\frac{1}{|I_{m,r} - I_{m,d}|} \right) \qquad d \neq r$$

In the case of equivalent yearly burden the consolidation is:

$$k_{t,d} = |\,(r - d)\,| \times |\,K_{t,d}\,| \qquad d \neq r \quad (24)$$

or even:

$$k_{t,d} = (r - d)\, K_{t,d} \qquad d \neq r$$

When Inflation Equals Rate of Return

A special case arises when the inflation rate is equal to the rate of return on investment, that is

Treatment of Various Costs in One Example

Problem—A heat exchanger uses steel tubes that cost \$10,000 and last 4 years with a \$2,000 salvage value. Cost for cleaning the tubes is \$3,000/year. At the beginning of the third year the outside of the tubes must be cleaned at a cost of \$4,000. During the fourth year there is an extra maintenance expense of \$1,500.

It's proposed to substitute alloy tubes that cost \$95,000, last 10 years and have a \$20,000 salvage value. Maintenance for the alloy tubes is \$1,000/year and the savings from increased production are \$6,000/year, giving a net operating expense of minus \$5,000/year.

All the above costs are in terms of the present dollar. Money is worth 8%/year after taxes, income tax is 52%, capital gains tax is 25% and the inflation rate is 4%/year.

Does it pay to install the alloy tubes?

Solution—Capitalized cost of the steel tubes is obtained from Eqs. (4), (7), (5), and (6) twice, in order:

$$C_d\,(1 - 0.52\psi_{4,8\%}) \left(\frac{I_{4,8\%}}{I_{4,8\%} - I_{4,4\%}} \right) =$$

$$(10{,}000 - 2{,}000)\,(0.5529)\,(7.138) = \$31{,}570$$

$$L \left(1 + \frac{1}{G_{4,4\%}} \times \frac{g}{I_{4,8\%} - I_{4,4\%}} \right) =$$

$$(2{,}000) \left(1 + \frac{1}{5.887} \times \frac{0.25}{1.3605 - 1.1699} \right) = 2{,}460$$

$$M\,(1 - 0.52\psi_{1,8\%}) \left(\frac{1 + r}{r - d} \right) =$$

$$(3{,}000)\,(0.5185)\,(27.00) = 42{,}000$$

$$B_3\,(1 - 0.52\psi_{1,r})\, I_{3,4\%} \left(\frac{I_{3,8\%}}{I_{4,8\%} - I_{4,4\%}} \right) =$$

$$(4{,}000)\,(0.5185)\,(1.0816)\,(6.119) = 13{,}730$$

$$B_4\,(1 - 0.52\psi_{1,r})\, I_{3,4\%} \left(\frac{I_{1,8\%}}{I_{4,8\%} - I_{4,4\%}} \right) =$$

$$(1{,}500)\,(0.5185)\,(1.1249)\,(5.666) = 4{,}960$$

$$K_{t,d} = \$94{,}720$$

Capitalized cost of the alloy tubes is obtained from Eqs. (4), (7) and (5), in order:

$$C_d\,(1 - 0.52\psi_{10,8\%}) \left(\frac{I_{10,8\%}}{I_{10,8\%} - I_{10,4\%}} \right) =$$

$$(95{,}000\text{–}20{,}000)\,(0.6112)\,(3.181) = 145{,}820$$

$$L \left(1 + \frac{1}{G_{10,4\%}} \times \frac{g}{I_{10,8\%} - I_{10,4\%}} \right) =$$

$$(20{,}000) \left(1 + \frac{1}{2.082} \times \frac{0.25}{2.1589 - 1.4802} \right) = 23{,}940$$

$$M\,(1 - 0.52\psi_{1,r}) \left(\frac{1 + r}{r - d} \right) =$$

$$-\,(5{,}000)\,(0.5185)\,(27.00) = -\,70{,}000$$

$$K_{t,d} = \$99{,}760$$

It doesn't pay to install the alloy tubes with a capitalized cost of \$99,760 against \$94,720 for the steel tubes.

$d = r$. Both the true and extended capitalized costs become infinite and cannot be used.

Such problems must be worked out on the basis of equivalent yearly burden. Usually the equations for equivalent yearly burden take the form of zero divided by zero. But, these can be evaluated further by use of the calculus. Final equations corresponding to Eqs. (4), (5), (6), (7), (8), (11) and (12), are respectively:

$$k_{t,d} = (C_d/m)\,(1 - t\psi_{m,r})\,(1 + r) \qquad d=r \quad (25)$$

$$k_{t,d} = M\,(1 - t\psi_{1,r})\,(1 + r) \qquad d=r \quad (26)$$

$$k_{t,d} = (B_x/m)\,(1 - t\psi_{1,r})\,(1 + r) \qquad d=r \quad (27)$$

$$k_{t,d} = L\left(\frac{g}{m}\right)\left(\frac{1+r}{F_{m,r}}\right) \qquad d=r \quad (28)$$

$$k_{t,d} = N\,(0) = 0 \qquad d=r \quad (29)$$

$$k_{t,d} = \left(\frac{C_w'}{m}\right)\left(\frac{1+r}{F_{m,r}}\right) \qquad d=r \quad (30)$$

$$k_{t,d} = rC_w \qquad d=r \quad (31)$$

Problem 5—An article costs \$10,000 and lasts one year. How much can we afford to pay for an article that lasts 10 years if both the return on investment and inflation rates are 8%/year and the income tax is 52%?

Solution—By using Eq. (25) we can find the equivalent yearly burden for the 1-year article:

$$k_{t,d} = (10{,}000/1)\,(1 - 0.52\psi_{1,8\%})\,(1.08)$$
$$= (10{,}000)\,(0.5185)\,(1.08)$$
$$= 5{,}600$$

Using the same equivalent yearly burden for the 10-year article:

$$5{,}600 = (C_d/10)\,(1 - 0.52\psi_{10,8\%})\,(1.08)$$
$$= (C_d/10)\,(0.6112)\,(1.08)$$
$$C_d = \$84{,}840$$

For a Fast Write-Off

If a facility lasting m years is written off for tax purposes in m' years, the only factor that must be altered is ψ. The ψ factor corresponds to the years in which the facility will be written off for tax purposes. In all other factors use the years corresponding to the life of the facility. For example, Eq. (4) becomes:

$$K_{t,d} = C_d\,(1 - t\psi_{m,r}')\left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}}\right)$$

Problem 6—A plant costing \$1 million will last 10 years but has a government certificate of necessity permitting writing off the entire investment in 5 years.

Money is worth 8%/year after taxes, income tax is 52% and the inflation rate is 4%/year. Express the savings due to the fast write-off as a present value.

Solution—For the normal 10-year write-off:

$$K_{t,d} = (1{,}000{,}000)\,(1 - 0.52\psi_{10,8\%})\left(\frac{I_{10,8\%}}{I_{10,8\%} - I_{10,4\%}}\right)$$
$$= (1{,}000{,}000)\,(0.6112)\,(3.181)$$
$$= \$1{,}944{,}200$$

For a 5-year write off:

$$K_{t,d} = (1{,}000{,}000)\,(1 - \psi_{5,8\%})\left(\frac{I_{10,8\%}}{I_{10,8\%} - I_{10,4\%}}\right)$$
$$= 1{,}000{,}000\,(0.5634)\,(3.181)$$
$$= \$1{,}792{,}200$$

Expressed as a capitalized cost, the advantage is:

$$\$1{,}944{,}200 - 1{,}792{,}200 = \$152{,}000$$

which is \$6,080 → expressed as the equivalent end-of-year yearly burden.

$$(0.04)\,(152{,}000) = \$6{,}080 \rightarrow$$

Present value for 10 years is:

$$6{,}080\left[\frac{1}{1+r} + \frac{(1+d)}{(1+r)^2} + \ldots + \frac{(1+d)^9}{(1+r)^{10}}\right]$$
$$= 6{,}080\left[\frac{1}{(r-d)} \times \frac{(1+r)^{10} - (1+d)^{10}}{(1+r)^{10}}\right]$$
$$= \$47{,}770$$

To Apply to an Entire Venture

Capitalized cost can be applied to an entire venture. By combining Eqs. (4), (6), (12) and (7) we have:

$$K_{t,d} = C_d\,(1 + t\psi_{m,r})\left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}}\right) +$$
$$\left(1 - \frac{t}{1+r}\right)\left(\frac{I_{m,r}}{I_{m,r} - I_{m,d}}\right)\sum_{x=1}^{x=m}\frac{B_x I_{(x-1),d}}{I_{(x-1),r}} +$$
$$C_w\left(\frac{r}{r-d}\right) + L\left(1 + \frac{1}{G_{m,d}} \times \frac{g}{I_{m,r} - I_{m,d}}\right) \quad (32)$$

Here C_d is the depreciable part of the initial cost of a facility lasting m years; B_x is the net yearly expense before taxes and depreciation (referred to the beginning of the year and in terms of the present dollar); C_w is the working capital with the understanding that it will have to be increased each year to keep in step with inflation; and L is the salvage value in terms of the present dollar.

For most years B_x must be negative, a net income, if a project is to pay off. If $K_{t,d}$ is negative, then the project pays off at a rate better than r. If $K_{t,d}$ is positive, the project won't pay off at the rate r, but it isn't necessarily a loser since it might pay off at some return less than r.

As written, Eq. (32) is for situations where $r > d$. If $d > r$, then a relationship similar to Eq. (32) can be written down by adding Eqs. (15), (17), (21) and (18)—these equations being based on the extended capitalized cost.

If $r = d$, the evaluation must be made on the basis of the equivalent yearly burden by adding Eqs. (25), (27), (31) and (28).

This inclusion of all three rates—return on investment, income tax and inflation—is intriguing. It might be supposed that the relationships are too involved to express simply and exactly and that a tedious trial and error calculation would be required. But this isn't the case since all three rates can be handled together as we've shown.

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2. Jelen, F. C., *Chem. Eng.*, May 1956, pp. 165-169.
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Guide to Treating-Solution Addition

Known Quantity ⇩		To Convert to: *Tp*	*Tl*	*Rc*	*Rg*
Concentration:	*Tp*, wt. %	.....	$X \cdot Tp$	$63.1\ Y/Tp$	Y/Tp
Concentration:	*Tl*, lb. chemical/gal. solution	Tl/X	.....	$63.1\ Z/Tl$	Z/Tl
Rate:	*Rc*, cc./min.	$63.1\ Y/Rc$	$63.1\ Z/Rc$	.....	$Rc/63.1$
Rate:	*Rg*, gal./hr.	Y/Rg	Z/Rg	$63.1\ Rg$	.....

Where $X = 8.33\ G_t/P$; $Y = Q\ U/167\ G_t$; $Z = Q\ U/20\ P$

Note: Factors are dimensional. Use units for variables as specified in nomenclature (next page).

HELP FOR YOUR

Chemical Proportioning Calculations

Handy factors and equations give speedy solutions to many types of blending, diluting and chemical treating problems.

JOHN R. HEFLER, Proportioneers, Inc., Providence, R. I.*

Accurate process control involves material balances in terms of weight units, although flow rates through proportioning pumps, positive displacement meters, or batch tanks are usually expressed in volumetric units. Accordingly, relationships between volume flows and weight concentrations are very useful in plant practice.

Typical proportioning problems in chemical processes include:

- Making up solutions for treating a given stream with a predetermined dosage of chemical;
- Predicting the volume of solutions required to produce a certain quantity of a particular weight concentration;
- Adjusting the concentration of an available solution to a desired weight percentage.

Calculation Methods

The following relationships cover the most common calculations for continuous blending, diluting and treating aqueous solutions based on volumes, specific gravities and weight concentrations. The formulas are also useful for batch operations based on volumes and for continuous proportioning of volumetric rates of flow.

* Meet your author on page 167.

Any consistent system of units of volume, weight and time can be used in most cases. However, the factors that are not dimensionless refer to volumes and weights as specified, and are indicated by an asterisk.

Chemical Treating Table—In making calculations involving the preparation and addition of treating solutions to a water stream in which there is originally no treating chemical present, the table above is used. Find the Known Quantity in the table. Select the expression which is in the vertical column representing the desired quantity. Solve for the required quantity by substituting the proper values in the expression.

Ratio Equations—Select the equation in which the desired volume quantity is the only unknown. Substitute the known quantities and solve for the unknown value.

Blending and Diluting Calculations:

$$\left(\frac{V_s}{V_b}\right) = \left(\frac{G_b}{G_s}\right)\left(\frac{B - W}{S - W}\right) \quad (1)$$

$$\left(\frac{V_w}{V_b}\right) = \left(\frac{G_b}{G_w}\right)\left(\frac{S - B}{S - W}\right) \quad (2)$$

$$\left(\frac{V_s}{V_w}\right) = \left(\frac{G_w}{G_s}\right)\left(\frac{B - W}{S - B}\right) \quad (3)$$

(continued on p. 130)

Chemical and Liquid Proportioning:

$$\left(\frac{C}{V_b}\right) = 8.33\,G_b\left(\frac{B-W}{P-W}\right) \quad (4)^*$$

$$\left(\frac{C}{V_w}\right) = 8.33\,G_w\left(\frac{B-W}{P-B}\right) \quad (5)^*$$

$$\left(\frac{V_w}{V_b}\right) = \left(\frac{G_b}{G_w}\right)\left(\frac{P-B}{P-W}\right) \quad (6)$$

Note: When a solvent alone is used as one component of blend, $W = 0$. If water is the solvent, $G_w = 1.00$.

Trying Them Out

Take a look at the problem solutions below and observe the simple technique used to get answers directly from data. In all examples, the specific gravity values are taken from "Handbook of Physics and Chemistry."

Treating Solution Preparation—A water flow of 150 gpm. is to be treated with a chemical at the rate of 10 ppm. How many pounds of chemical per gallon of treating solution must be used if the solution is added to the water at 5 gph.? The dry chemical is 75% pure.

Since we have the known quantity of treating solution rate in gph., and we wish to get the desired concentration of treating solution in lb. chemical/gal. solution, enter the table and determine the expression to be (Z/Rg). Then,

$$\text{Treating solution concentration} = \frac{150 \times 10}{20 \times 75 \times 5}$$

$$= 0.20 \text{ lb. chemical/gal. solution}$$

The required solution strength in weight percent can be accurately determined only for very dilute solutions where G_t can be taken as 1.0. If concentrated reagent is required, the expression will be approximate unless a good estimate can be made of the specific gravity of the solution, or successive approximations are made from an initial assumed gravity. The required lb. of chemical per gal. of treating solution will be exact in every case.

Blending and Diluting—An acid wash process discharges 15 gpm. of spent sulfuric acid of 3% weight concentration. What rates of 98% acid and water must be used to return 17 gpm. of 10% acid to the process?

% H_2SO_4	Sp. Grav.
W = 3	G_w = 1.0184
B = 10	G_b = 1.0661
S = 98	G_s = 1.8361

(a) The known quantities are: $V_w = 15$ gpm., W, B, S, G_w, G_b and G_s. Use Eq. (3) to calculate V_s, the rate of 98% acid to blend with 3% acid (weak) to form 10% acid (blended).

$$\left(\frac{V_s}{V_w}\right) = \left(\frac{1.0184}{1.8361}\right)\left(\frac{10-3}{98-10}\right) = 0.044$$

$$V_s = 15 \times 0.044 = 0.66 \text{ gpm. 98\% acid}$$

Eq. (2) gives V_b, the rate of 10% acid (blended) produced from 15 gpm. of 3% acid (weak) and 0.66 gpm. of 98% acid.

$$\left(\frac{V_w}{V_b}\right) = \left(\frac{1.0661}{1.0184}\right)\left(\frac{98-10}{98-3}\right) = 0.97$$

$$V_b = \frac{15}{0.97} = 15.45 \text{ gpm. 10\% acid}$$

(b) Since the desired rate of V_b is 17 gpm., an additional 1.55 gpm. of 10% acid must be produced by diluting 98% acid with water. Substitute in Eq. (1), with $W = 0$ to find the rate of 98% acid, V_s, required.

$$\left(\frac{V_s}{V_b}\right) = \left(\frac{1.0661}{1.8361}\right)\left(\frac{10-0}{98-0}\right) = 0.0593$$

$$V_s = 1.55 \times 0.0593 = 0.092 \text{ gpm. 98\% acid}$$

Find V_w, the rate of water required to produce 1.55 gpm. of 10% acid, from Eq. (2). Again, $W = 0$, and $G_w = 1.00$.

$$\left(\frac{V_w}{V_b}\right) = \left(\frac{1.0661}{1.00}\right)\left(\frac{98-10}{98-0}\right) = 0.957$$

$$V_w = 1.55 \times 0.957 = 1.48 \text{ gpm. water}$$

Summary:

	gpm.
Total 98% acid = 0.66 + 0.092 =	0.75
Water =	1.48
3% acid (given) =	15.0
10% acid (required) =	17.0

Chemical and Liquid Proportioning—For 10 gpm. of 20% NaOH find the gpm. of water required and the pounds per minute of solid NaOH of 80% purity required. For 20% NaOH solution, $G_b = 1.2191$.

The known quantities are $V_b = 10$ gpm.; $B = 20$; $W = 0$; $P = 80$; $G_b = 1.2191$; and $G_w = 1.00$. Use Eq. (6) to calculate the water rate, V_w.

$$\left(\frac{V_w}{V_b}\right) = \left(\frac{1.2191}{1.00}\right)\left(\frac{80-20}{80-0}\right) = 0.914$$

$$V_w = 10 \times 0.914 = 9.14 \text{ gpm. water}$$

Eq. (4) gives the rate of solid NaOH to use, C.

$$\left(\frac{C}{V_b}\right) = 8.33 \times 1.2191\left(\frac{20-0}{80-0}\right) = 2.54$$

$$C = 10 \times 2.54 = 25.4 \text{ lb./min. NaOH}$$

* These equations are dimensional and apply only when V is expressed in gpm. and C in lb./min.

Nomenclature

B	Concentration of solute in blended solution, weight percent.
C	Flow rate of chemical to be blended, lb./min.
G	Specific gravity, water = 1.00.
P	Purity or availability of pure chemical in treating chemical, weight percent.
Q	Flow rate of water to be treated, gpm.
Rc	Treating solution flow rate, cc./min.
Rg	Treating solution flow rate, gal./hr.
S	Concentration of solute in strong solution, weight percent.
Tl	Concentration of treating solution, lb. chemical/gal. treating solution.
Tp	Concentration of pure chemical in treating solution, weight percent.
U	Pounds of pure chemical/million pounds of water to be treated, ppm.
V	Volumetric quantity involved, consistent units.
W	Concentration of solute in weak solution, weight percent.
X, Y, Z	Factors to convert known quantity to desired quantity.
Subscripts	
b	Blended solution.
s	Strong solution.
t	Treating solution.
w	Weak solution.

How to Solve Soft Packing Problems

New Light on a Way to Pack Pumps Which Will . . .

- **Prevent leakage, reduce cost, shaft and packing wear**
- **Use conventional stuffing box and packings**
- **Work with pressure or vacuum or abrasive liquids**
- **Operate successfully at extremely high pressures**
- **Eliminate all need for manual adjustment**
- **Cut supervision and maintenance to a minimum**

WALTER COOPEY, Engineering Consultant, Charleston, W. Va.*

It is generally appreciated in the process industries that packing life is an important factor in the performance of centrifugal pumps. Many articles have been written on the subject but these invariably deal with ideas for trying to obtain better pump performance with the conventional stuffing box.

Unfortunately, these articles do not advance solutions for the basic causes of the trouble. In spite of the many pages of specific instructions that have been written about the selection, care, installation and adjustment of packing, the results they can give at best are of indifferent value.

In fact, such specifications and instructions may be more confusing than enlightening to the average mechanic. Too much should not be expected of him if his supervisor doesn't know how packing should function.

In any mechanism where there are rubbing surfaces, wear will occur. The extent of this wear depends on the friction effect. When it can be done, friction can be greatly reduced by applying a lubricant to the critical spots. In the case of packing, adequate lubrication at the point of highest friction will simplify and almost eliminate most of the problems in fluid sealing, such as packing selection, packing life, shaft life, need for spare equipment and parts, maintenance, supervision, and process interruptions.

*Meet your author on page 164.

It will be explained later why lubrication is practically non-existent in the conventional stuffing box arrangement with soft plastic types of packing. We shall briefly examine the various ideas which have been advanced to alleviate bad conditions, and then we shall consider a relatively simple arrangement which has solved many difficult packing problems.

In Fig. 1 a conventional or standard stuffing box arrangement is diagrammed, consisting of a number of rings of packing separated by a lantern ring. In general, this is the arrangement used by practically all pump manufacturers for soft packing installations.

There may be minor variations, such as omitting the lantern or putting it at the bottom of the stuffing box, but usually such changes have little effect on the final results. Take-up on the packing to reduce or prevent leakage is obtained by manual adjustment of the gland at the discretion of a mechanic. This introduces the human factor, and may result in better or worse performance depending on the skill of the individual.

Inspection of a set of used packing will generally show that the greatest wear on both the packing and the shaft takes place under the last ring or two of packing next to the gland. These packing rings may be compressed to one-third or less of their original thickness. This effect progressively decreases toward the bottom of the stuffing box. In fact it is often found that the bottom rings of packing have their original dimensions.

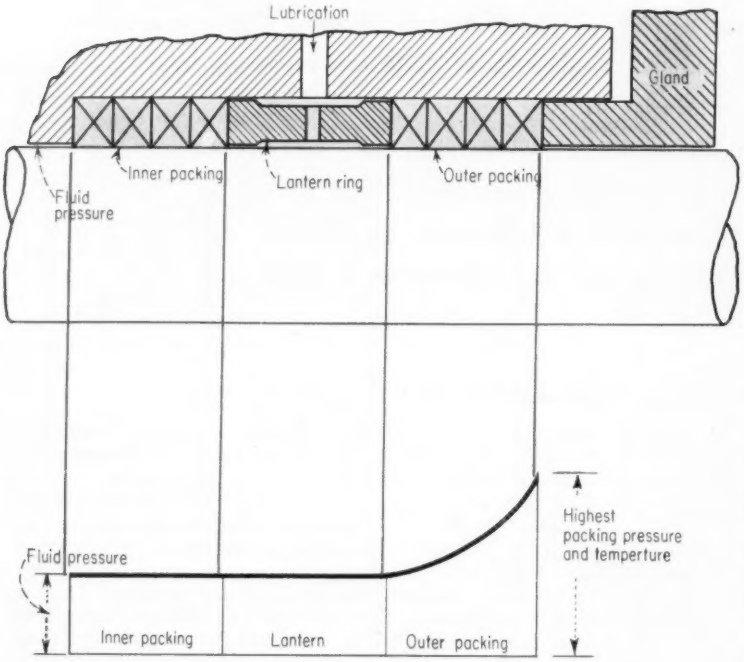
We can therefore assume that the pressure effect in the stuffing box is about as shown at the bottom of Fig. 1. The point of highest packing pressure and maximum friction is next to the gland. There may be not only the heat of the fluid to contend with, but also the extreme heat developed by packing friction. It is not surprising that the packing and shaft will have a very short life, even with moderately severe conditions of service.

It is a common assumption, that a lubricant introduced at the pressure side of packing will be forced to flow through the packing toward atmosphere, thus furnishing lubrication where it is needed. This is a faulty assumption. It is obvious from Fig. 1 and its pressure curve that lubricant supplied to the lantern can not get to the point of highest pressure and friction at the outer packing unless this packing is loose enough to permit leakage. Under such conditions excessive lubricant must be used to counteract the flow of liquid being pumped, which also moves in this direction.

On the other hand, if the packing is tight the lubricant will take the path of least resistance and pass into the pump casing with no benefit at the point where it is needed. This indicates the importance of the human factor. For best results the gland must be adjusted for just enough leakage.

1. Conventional packing has serious faults . . .

Since maximum pressure in the packing is next to the gland, lubricant rarely reaches there and severe shaft and packing wear may occur. Needed manual gland adjustment is seldom accurate.



This is quite a trick and the cards are stacked against it being done. Of course, if abrasives are present in the liquid, the problem is further complicated as there will be excessive wear on the shaft at the bottom of the stuffing box since there is nothing to resist the liquid's working toward the lantern.

Following are a few of the suggested but inadequate recommendations for improving packing life with the conventional stuffing box.

1. *Extra Deep Stuffing Box*—This is of little value and may actually make matters worse because it will result in a higher pressure at the outer packing rings. The wear on the shaft will be increased and additional packing life is due to the insurance provided by the extra packing.

2. *Use Flushing Liquid Through Lantern*—Water is often recommended. It is easy to pack against if leakage is permissible. If water in the pumped liquid is not important (it is in many processes), this may be of some benefit. There is still the problem of regulation to permit the right amount of leakage. Furthermore, water is far from the ideal lubricant.

3. *Use Different or Better Packing*—This is an incremental improvement as long as some of the "built-in" lubricant remains. The basic troubles are still present.

4. *Water-Jacket Stuffing Box*—Practically all soft packings are made from materials with fair insulating properties. Therefore, any cooling effect would be insignificant where it is needed.

5. *Increase Shaft Diameter*—This idea is based on the supposition that packing trouble is due to the shaft being too light. If it is, it is a design matter that can easily be checked. However, the larger the shaft, the greater the rubbing speed, meaning increased duty for the packing.

6. *Flush Abrasives From Stuffing Box*—This is fine but is not always easy to do. Much depends on the flushing liquid and what its effect will be on the pumped liquid. There is still the problem of packing against this liquid.

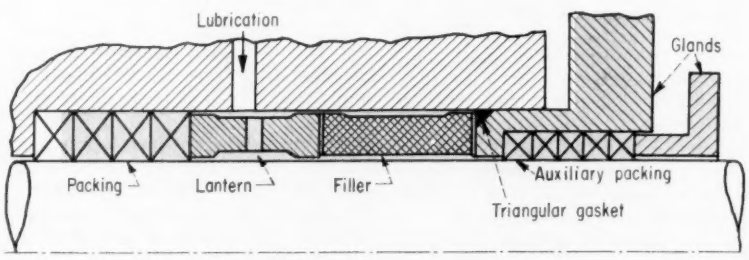
7. *Change to Mechanical Seal*—The mechanical seal is an excellent packing but is not a "cure all" and has definite limitations. There are almost as many articles published about seal troubles and how to remedy them as there are about soft packing. Because they are precision made, mechanical seals should be installed and maintained by trained personnel.

In approaching the problem of supplying lubrication to the point of highest pressure and friction, I considered various ideas to accomplish this. The first one I tried is shown in Fig. 2. Note that the outer packing is replaced by a filler piece so that the gland pressure is applied directly to the packing at the bottom of the stuffing box.

In this design, sealing between the filler and the gland at the bore of the stuffing box is obtained by a triangular gasket. Shaft sealing is provided by boring out the gland

2. First revised design . . .

Gave better results than conventional packing but still needed manual adjustment and was quite complex to build and maintain.



to make an auxiliary stuffing box. These features accomplished the immediate objective in that the main packing could be lubricated where it would do the most good—next to the lantern. The performance was better than that obtained than with the conventional stuffing box. But it was not good enough. The human factor still affected performance and the design was more complicated.

The next step in the development is shown in Fig. 3. This consisted of putting a helical spring in the bottom of the stuffing box with the objective of reducing the effect of the human factor. This it did but it moved the pressure point of the main packing to the bottom of the stuffing box, which was a change in the wrong direction. The results seemed neither better nor worse than those with Fig. 2.

However, the experience obtained with these designs resulted in a "light dawning." The picture of what the answer should be suddenly became clear. Once again the age-old question arose: "Why didn't someone think of it before."

In Fig. 4 we see the final step in the evolution. It discloses a packing arrangement which removes most of the limitations that have been inherent in soft or plastic packing applications since the origin of the stuffing box. Although minor modifications may be required depending upon the service conditions, the basic design is essentially as shown. In effect, the lantern has simply been replaced by a helical spring, but this completely changes the manner in which the packing functions.

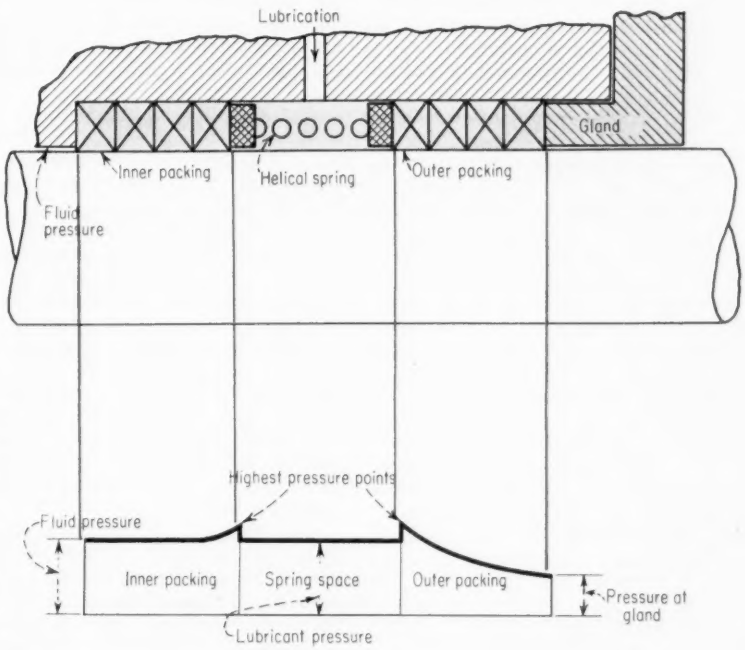
Instead of the highest friction point being next to the gland as in Fig. 1, there are now two points at each end of the spring. However, these are exposed directly to the lubricant. If its pressure is the same as the fluid pressure, the inner packing has just a slight differential across it and the packing acts very much as a diaphragm. There is almost balanced pressure. The outer packing is required only to retain the lubricant pressure. This is relatively easy to do because the lubricant is in direct contact with the point of highest pressure and friction. The spring compensates for any slight wear or compression of the packing.

This arrangement removes the human factor from the equation because, when the packing is installed, the gland is pulled up to the face of the stuffing box and no further adjustment is required. The spring takes care of any thermal expansion or swelling of the packing. There are several ways in which the lubricant pressure can be developed but this has never been a problem. If the pressure curves in Figs. 1 and 4 are compared, it will be apparent why there is no similarity in the performance of these packing arrangements.

If the liquid being pumped has any lubricating properties, then the packing at the bottom of the stuffing box can be dispensed with. This is the easiest type of service but, even so, it is something of a prob-

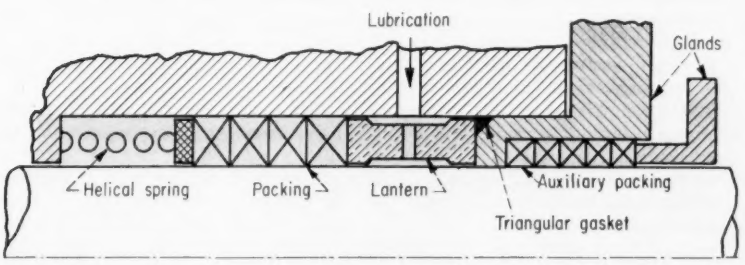
4. Final design cured the faults . . .

Coopey packing is simple, low in cost, easy to install and maintain. Needs no adjustment, reduces wear, uses ordinary packings, handles pressure, vacuum, abrasives, fits any stuffing box.



3. Second revised design . . .

Eliminated need for manual adjustment but moved point of maximum pressure in wrong direction, worked no better than Fig. 2.



lem with the conventional packing arrangement. Also, for very high temperatures above what the packing will stand, the lubricant can be cooled and circulated through the space occupied by the spring. However, as packing friction is negligible, this is not as important as it is in conventional packing.

It is said that packing is not an exact science because there are too many variables and that experience is the only answer. There is much truth in this statement. However, if the number of variables can be reduced, there is less need for guesswork and this is what the arrangement in Fig. 4 accomplishes. It has often been demonstrated that packing which failed quickly in the conventional arrangement would give excellent performance in the improved arrangement. Such packing approaches the requirements for the ideal packing, since there is a low coefficient of friction, elimination of abrasive effect, prevention of leakage, and provision for automatic adjustment.

Summarizing, the advantages of the author's packing are:

1. Simplicity.
2. Low cost.
3. Flexibility.
4. Long packing life.
5. Long shaft life.
6. Suitable in practically any service with rotating shafts.
7. Very low maintenance.
8. Can be applied to existing installations.
9. Can use conventional types of soft and plastic packings.
10. Does not require highly trained personnel.
11. Is good for vacuum as well as pressure.
12. Permits no leakage.
13. Abrasives in the fluid present no problem.
14. Minimum supervision.

Even though this stuffing box arrangement can reduce the severity of packing duty to a minimum, there are several basic principles that should be observed to obtain the very best performance in any packing application. These are worth mentioning.

Alignment—The importance of good shaft alignment increases as the service becomes more difficult.

Quality of Materials—The material for a shaft is determined by the liquid with which it comes in contact. There are many types of stainless steel and other alloys for corrosive conditions, some of which can be heat-treated or surface-hardened. In the non-corrosive field are many metals that can be carburized, nitrided, heat-treated, chromium-plated or otherwise surface-hardened for wear.

Packings, also, should be selected for the service conditions and here again there is a wide selection from which to choose. However, it is best for packing to be purchased from the manufacturer in ring form, dimensioned to fit the shaft and stuffing box. If packing is cut from a coil it is difficult to obtain a good fit and we must depend on the skill of the man doing the job. Chevron and Vee packings, if they can be used, will permit the stuffing box to be made shorter.

Finish of Materials—Wearing-in means wearing-out and it is much better to start with a good finish than it is to try to obtain one by a lengthy breaking-in period. With formed packing and a shaft polished to about 5 microinches, we can eliminate this procedure.

Lubrication — Although hydrodynamic lubrication is most desirable, it is necessary to depend upon boundary lubrication with soft packing. "Built-in" lubrication is of value only for very easy services. Even then, it is just a question of time, usually short, until it is dissipated. Therefore, for tough service, a constant supply of lubricant is desirable. Very little is required if properly applied, but it must reach the point where it will do the most good.

Some investigators have shown that even with hydrodynamic lubrication a film as thin as 0.00001 in. will suffice. The supply must be constant and there are many ways in which this can be obtained. If contamination is a problem, some thought should be given to selecting a lubricant which is compatible with the liquid being handled. This may not need to be a mineral oil or grease. This has proven not to be very critical with the Fig. 4 arrangement.

Type of Arrangement—This can be modified for the service. However, I can say without reservation that, even with the best efforts to improve its performance, the conventional arrangement will not be very good. It is questionable whether it should be used even for clean water.

Care in Application—Too often, when packing troubles are serious, there is a tendency to have someone—almost anyone—simply replace or add packing. This may be compounding trouble. Those responsible for the maintenance of pumps should have a good working knowledge of the fundamentals and functions of packing. In the process industries continuity of pump operation may be much more important than the mechanical efficiency of the pump. There have been instances where getting a process into production has been delayed at high cost simply because of unsatisfactory pump packing performance.

Proof of the Pudding

To illustrate what can be accomplished with the right packing arrangement, consider the case of a pump that delivered a liquid which contained 10% abrasives at 200 psi. and a temperature of 600 F. The shaft diameter was 2½ in. and had a speed of 3,500 rpm. Since the rubbing speed was almost 2,300 ft. per min., this would be a tough service even with clean liquid.

With the conventional packing arrangement the packing life was not much over 24 hr., even with lubricant consumption running as high as a barrel per day. A mechanical seal failed in less than 8 hr. Undoubtedly the latter could have been revised to give better results but the experimental work would have been costly and would have interfered with operations. After a trial the Coopey packing installation was accepted as being very satisfactory.

Delivery pressure in the foregoing case was not particularly high but agitator shafts in autoclaves at pressures up to 5,000 psi have been packed in this way and have given good performance even when it was important that no lubricant enter the vessel. I have not determined what the upper limit of pressure is for the packing but it is conceivable that the same basic principles can be applied for pressures several times higher than 5,000 psi.

The same general principles have been used very satisfactorily in applying soft packings to other types of rotating shafts than those used in pumps. However, this arrangement should not be used for reciprocating rods. That's another story.

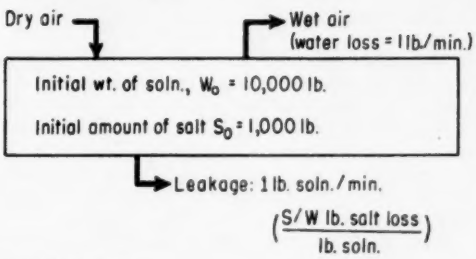
TYPICAL ENGINEERING PROBLEM:
Calculate Change in Salt Concentration With Respect to Time

From the material balance, write differential equation:

$$\frac{ds}{d\theta} = -\frac{s}{10{,}000 - 2\theta}$$

Regroup variables:

$$\frac{ds}{s} = -\frac{d\theta}{10{,}000 - 2\theta}$$



It now fits a standard equation = $f(x)dx + g(y)dy = 0$

$$\frac{ds}{s} + \frac{d\theta}{10{,}000 - 2\theta} = 0$$

FIRST—SET UP EQUATION THEN . . .

Fit Differential Equation to Standard Form

You can save time by using the standard solution to differential equations which are derived in many chemical engineering problems.

WILLIAM E. BALL, Washington University, St. Louis, Mo.
R. CURTIS JOHNSON, Compumatix, Inc., St. Louis, Mo.*

In the previous sections, we expended considerable effort in explaining, detail by detail, how to set up mathematical statements of problems. However, we will not treat equation solution with the same thoroughness. There are three reasons for this approach.

The set up of problems is the engineer's business. Only he has the proper understanding of a physical situation to make the most reasonable problem analysis. On the other hand, the problem solution is a job which may be handled by the engineer or mathematician.

While we advocate that problem solution be done with understanding rather than by crank-turning, we admit that crank-turning can accomplish wonders at times. The practical engineer knows when he should solve his own problems, and when he should consult a mathematician.

Our second reason for avoiding a complete treatment of the subject of differential equations is that the material cannot be presented thoroughly in such limited space.

In the third place, we assume that at least some study of formal differential equations is in the educational background of every engineer.

Solutions to Differential Equations

Having stated our philosophy regarding this subject, we now proceed to the summary we have prepared. In the table we list the more common types of first order ordinary differential equations. Their forms are shown, typical solutions where applicable are given and an example of each is shown.

We should emphasize that there are many classes of equations that we have not included. Also, there are many practical problems which lead to equations which are not easily placed in any class. In these cases real cleverness is necessary to find a method of analysis which gives the solution.

Sometimes analytical solutions are obtained. Often these require new functions. Some examples of functions arising from the necessity of solving applied problems are Bessel, Legendre, Hermite and Laguerre. In many cases analytical solutions do not exist; or their solutions are not known at the present

* For authors' biographies, see *Chem. Eng.*, Sept. 1957, pp. 343-344.

time. In such cases numerical, graphical and computer methods become essential.

How to Solve Applied Problems

The remainder of this article is devoted to the solution of examples. Practically every problem requires several steps in its solution. These are:

(1) The equation is classified if it fits into a standard form.

(2) Then the equation is solved by following the standard solution.

(3) Boundry conditions are applied. This means placing the upper and lower limits on integrals, evaluating constants of integration or otherwise fitting the known end or boundry conditions and eliminating all unknown constants.

(4) The final solution is checked in some manner to see that it truly represents the phenomena under consideration.

Problem 1—Solve the differential equation derived for Problem 2, *Chem. Eng.*, Sept. 1957, p. 288. [For easy reference the problem is repeated here.]

A large wooden storage tank initially contains 10,000 lb. of a 10% by weight solution of sodium chloride. A compressed air line, used occasionally for mixing the solution, leads to the bottom of the tank. By accident one night this air line is left open. A leak also developes near the bottom of the tank.

The solution leaks out at a rate of 1 lb./min. and the air flow is such that 1 lb. of water is evaporated per minute. Derive equations for the concentration of salt in the tank and the percent of the original salt remaining as a function of time.

The derived equations are

$$\frac{dS}{S} = -\frac{d\theta}{10{,}000 - 2\theta} \tag{1}$$

$$W = 10{,}000 - 2\theta \tag{2}$$

$$c = S/W \tag{3}$$

Here c = concentration, lb. salt/lb. solution; S = salt, lb.; W = solution, lb. and θ = time, min.

Solution—The equation is separable. (Type A in table). Therefore,

$$\int_{1{,}000}^{S} \frac{dS}{S} = -\int_{0}^{\theta} \frac{d\theta}{10{,}000 - 2\theta}$$

$$\log_e\left(\frac{S}{1{,}000}\right) = \log_e\left[\left(\frac{10{,}000 - 2\theta}{10{,}000}\right)^{1/2}\right]$$

$$S = 1{,}000\left(\frac{10{,}000 - 2\theta}{10{,}000}\right)^{1/2} \tag{4}$$

Using Eqs. (2) and (3)

$$c = 10/(10{,}000 - 2\theta)^{1/2} \tag{5}$$

Note that we have now fulfilled three steps of our outline. We have classified and solved the equation; and have put in the known boundary conditions. Can we now ascertain whether the final solutions are reasonable?

We know that the amount of salt in the tank must decrease. Also, its absolute rate of decrease must increase since the solution leaks out at a constant rate. However, its concentration is increasing. The equation for S must show this. The equation for c must show an increase in both c and in the rate of c, since there is a constant rate of removal of solvent by evaporation and a constantly decreasing amount of solution from which this solvent is removed.

We should also point out that if we let θ become too large, the solution becomes indeterminate. This is true because either the tank becomes empty or all the solvent is removed. We are then trying to express composition greater than unity.

From Eqs. (4) and (5) we see that S decreases and c increases as θ increases. Differentiating Eq. (4) gives

$$\frac{dS}{d\theta} = -\frac{10}{(10{,}000 - 2\theta)^{1/2}} \tag{6}$$

Here $dS/d\theta$ is negative as it must be; and its absolute value increases as θ increases.

Differentiating Eq. (5) results in the following:

$$\frac{dc}{d\theta} = \frac{10}{(10{,}000 - 2\theta)^{3/2}} \tag{7}$$

Here $dc/d\theta$ is positive and it increases as θ increases. Thus our known trends in S and c are satisfied.

Problem 2—Consider a tank for batch heating a liquid. Heat is supplied by means of a steam jacket. Tank volume is V, cu. ft. Liquid density is ρ, lb./cu. ft. and heat capacity c, Btu./lb.-deg. F.

Overall heat transfer coefficient is U, Btu./hr.-sq. ft.-deg. F., heated area is A, sq. ft. and temperatures of steam and liquid are T_s and T, deg. F. Derive and solve the equation for T as a function of time, θ.

With constant U, A, c and ρV product, we derived the differential equation

$$dT/d\theta = (UA/\rho cV)\,(T_s - T)$$

(See *Chem. Eng.*, Sept. 1957, Problem 3, p. 292 for derivation of above equation.)

Solution—The equation is separable. Thus,

$$dT/(T_s - T) = (UA/\rho cV)\,d\theta \tag{8}$$

which gives the solution

$$-\log_e(T_s - T) = (UA/\rho cV)\,\theta \tag{9}$$

We must now place limits on the variables. If we define $\theta = 0$ when $T = T_o$ as the starting conditions, we have the necessary boundry conditions. Then

$$\log_e\left(\frac{T_s - T}{T_s - T_o}\right) = -\frac{UA}{\rho cV}\,\theta \tag{9}$$

We may also write Eq. (9) in other forms. These are more suitable in some cases.

$$\frac{T_s - T}{T_s - T_o} = \exp\left[-\left(\frac{UA}{\rho cV}\right)\theta\right] \tag{10}$$

$$\frac{T - T_o}{T_s - T_o} = 1 - \exp\left[-\left(\frac{UA}{\rho cV}\right)\theta\right] \tag{11}$$

Here $\exp[-(UA/\rho cV)\theta]$ is equal to e^x where $x = -(UA/\rho cV)\theta$. We may look on $(T - T_o)/(T_s - T_o)$ as the fraction of maximum possible temperature change; and the exponential term as a measure of unaccomplished change.

This form is particularly familiar to men in the control fields as a representative example of the response of a first order linear system to a step input. Chemical engineering literature contains many examples of equations like Eq. (11).

We now ask whether the solution is representative of the phenomena being analyzed. When $\theta = 0$, $T = T_o$ which is true. As θ increase T approaches T_s

Some of the Most Useful First Order Differential Equations

A. Variables Separable: $f(x)\,dx + g(y)\,dy = 0$

Solution: $\int f(x)\,dx + \int g(y)\,dy = C$

Example: If $x^2\,dx + y^3\,dy = 0$, then $\frac{1}{3}x^3 + \frac{1}{4}y^4 = C$. If, on integration, definite limits are used, then $C = 0$
Note that type A is a special case of type B.

B. Exact: $M(x, y)\,dx + N(x, y)\,dy = 0$ where $\partial M/\partial y = \partial N/\partial x$

Solution: Let $F = \left[\int M\,dx\right]_{y_{const}}$ Then the solution is: $F + \left[\int \left(N - \frac{\partial F}{\partial y}\right) dy\right]_{x_{const}} = C$

Or let $G = \left[\int N\,dy\right)_{x_{const}}$ Then the solution is: $\left[\int \left(M - \frac{\partial G}{\partial x}\right) dx\right]_{y_{const}} + G = C$

Use the one that requires the least integration effort.

Example: If $(2x + y)\,dx + (x + 2)\,dy = 0$, then $\partial M/\partial y = 1 = \partial N/\partial x$. Hence the equation is exact.

$F = \int M\,dx = x^2 + xy \qquad \frac{\partial F}{\partial y} = x \qquad N - \frac{\partial F}{\partial y} = 2 \qquad \int \left(N - \frac{\partial F}{\partial y}\right) dy = 2y$

Hence the solution is $x^2 + xy + 2y = C$.

C. Homogeneous: $M(x, y)\,dx + N(x, y)\,dy = 0$ where M and N are homogeneous functions of the same degree.
A homogeneous function of degree M is defined if $f(tx, ty) = t^m f(x, y)$.

Solution: Substituting $y = wx$ reduces the equation to one where the variables are separable.

Example: Let $(x^2 + y^2)\,dx + xy\,dy = 0$. Here $(tx)^2 + (ty)^2 = t^2(x^2 + y^2)$ and $(tx)(ty) = t^2(xy)$
Here M and N are homogeneous functions of degree 2.
Let $y = ux$. Differentiating gives $dy = u\,dx + x\,du$.
Substituting in original equation: $x^2(1 + 2u^2)\,dx + ux^3\,du = 0$.
Then separating variables and integrating: $\log_e x + \frac{1}{4}\log_e(1 + 2u^2) = \log_e C$.

Hence the final solution is $x = C[1 + 2(y/x)^2]^{-1/4}$ where $u = y/x$.

D. Linear: $dy/dx + P(x)y = Q(x)$

Solution: $y = e^{-\int P dx}\left[\int Q e^{\int P dx} + C\right]$

Example: Let $\frac{dy}{dx} + \left(\frac{1}{x}\right)y = 2x$. Then $e^{\int P dx} = e^{\int (1/x) dx} = e^{\log_e(x)} = x$

and $\int Q e^{\int P dx}\,dx = \int 2x^2\,dx = \frac{2}{3}x^3$

Hence the solution is $y = \frac{1}{x}\left[\frac{2}{3}x^3 + C\right]$ or $y = \frac{2}{3}x^2 + \frac{C}{x}$

E. Bernoulli: $dy/dx + P(x)y = Q(x)y^n$

Solution: Divide equation by y^n and substitute $u = y^{1-n}$. This operation yields a linear equation, type D.

Example: Steps follow example in type D.

which is also true. The rate of change of temperature is

$$\frac{dT}{d\theta} = (T_s - T_o)\left(\frac{UA}{\rho c V}\right)\exp\left[-\left(\frac{UA}{\rho c V}\right)\theta\right] \qquad (12)$$

This rate is positive since the liquid is being heated. Also, the rate decreases as θ increases. We know that this is true if A, U and the liquid properties remain constant and that the temperature driving force decreases. We conclude that our solution meets the tests we apply to it.

Problem 3—Initally a tank contains 100 cu. ft. of a salt solution with a concentration of 2 lb./cu. ft. At a given time a solution with a concentration of 1 lb./cu. ft. is fed into the tank at 10 cfm. At the same time solution is removed from the tank at 5 cfm. Derive and solve equations representing the change in total material and concentration in the tank as functions of time.

The equations which were derived in *Chem. Eng.*, Sept. 1957, Problem 1, p. 288 are

$$10 - 5c = A\,dc/d\theta + c\,dA/d\theta \qquad (13)$$

$$dA/d\theta = 5 \text{ cfm.} \qquad (14)$$

where A is a general term to represent accumulation.

Solution—Using boundry conditions, we eliminate

Plot Graph to Check Equation

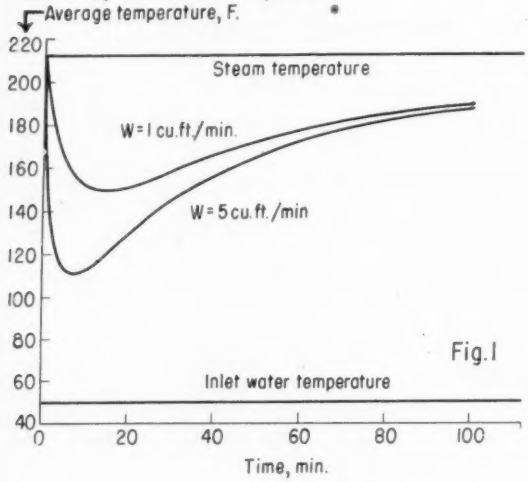


Fig. 1

Time θ Min.	Temperature, Deg. F. $W = 1$	$W = 5$
0	212	212
1	197.7	160.0
2	186.7	136.0
5	165.8	113.0
10	152.2	112.3
20	151.2	129.0
50	171.6	165.4
100	189.1	187.3

one of the variables in the two simultaneous equations. Solving Eq. (14) with $A = A_o$ when $\theta = 0$ gives

$$A - A_o = 5\theta \tag{15}$$

But, A_o is given as 100 cu. ft. which gives

$$A = 100 + 5\theta \tag{16}$$

$$10 - 5c = (100 + 5\theta)\, dc/d\theta + 5c \tag{17}$$

Eq. (17) is separable and is written as follows:

$$dc/(10 - 10c) = d\theta/(100 + 5\theta) \tag{18}$$

$$\frac{1}{10}\left(\frac{dc}{1-c}\right) = \frac{1}{5}\left(\frac{d\theta}{20+\theta}\right) \tag{19}$$

After integrating Eq. (19) we get

$$-\log_e(1 - c) = 2\log_e(20 + \theta) \tag{20}$$

With the boundry value that $c = 2$ lb. /cu. ft. when $\theta = 0$, we rearrange the equation and insert these values.

$$\log_e\left(\frac{c-1}{2-1}\right) = -2\log_e\left(\frac{20+\theta}{20}\right)$$

$$= \log_e\left[\left(\frac{20+\theta}{20}\right)^{-2}\right] \tag{21}$$

Or, after finding antilogs, we get

$$c = 1 + \left(\frac{20}{20+\theta}\right)^2 \tag{22}$$

Again we ask whether the solution is reasonable. When $\theta = 0$, $c = c_o = 2$. As θ increase, c approaches 1. These are known conditions. The rate of change of c is

$$\frac{dc}{d\theta} = \frac{-2(20)^2}{(20+\theta)^3} \tag{23}$$

This rate equation shows that c decreases as θ increases; and the rate of decrease of c decreases and approaches zero as θ increases. Both facts are known from observation of the physical system.

Problem 4—Initially a cylindrical tank five feet in diameter contains 10 cu. ft. of water at 212 F. The tank is heated by means of a steam jacket with steam condensing at 212 F. Water at 50 F. is then introduced at a constant rate of 1 cfm. As water is added, the surface available for heat transfer increases at the rate of 0.8 sq. ft. /cu. ft. of water.

What is the average water temperature as a function of time? Consider the tank well agitated so that temperature of the water is uniform. Assume over all heat transfer coefficient U is constant at 300 Btu./hr.-sq. ft.-deg. F.

In *Chem. Eng.*, Sept. 1957, Problem 5, p. 294 we derived the following equation:

$$\frac{dT}{d\theta} + \left[\frac{W}{V_o + W\theta} + \alpha\right] T = \left[\frac{W}{V_o + W\theta}\right] t_w + \alpha t_s$$

where

c_p Heat capacity, 1 Btu./lb.-deg. F.
T Water temperature, deg. F.
t_s Steam temperature, 212 F.
t_w Inlet water temperature, 50 F.
V_o Initial volume in tank, 10 cu. ft.
W Rate of addition of water, 1 cfm.
α $0.8\,U/c_p\,\rho$.
θ Time, consistent units.
ρ Density, 62.4 lb./cu. ft.

Solution—The only variable quantities in the equation are the water temperature and time. The problem is whether the equation can be put into a standard form or whether numerical or graphical methods must be used.

Rearranging terms [note $dT = d(T - t_s)$],

$$\frac{d(T-t_s)}{d\theta} + \left[\frac{W}{V_o + W\theta} + \alpha\right](T - t_s) = \left(\frac{W}{V_o + W\theta}\right)(t_w - t_s) \tag{24}$$

This is a first order linear equation. Rewriting Eq. (24) into standard form, type D, gives

$$\frac{d(T-t_s)}{d\theta} + P(\theta)(T - t_s) = Q(\theta)$$

The standard solution follows:

$$(T - t_s)\, e^{\int P d\theta} = \int e^{\int P d\theta} Q d\theta + k$$

$$\int P d\theta = \log_e(V_o + W\theta) + \alpha\theta$$

$$e^{\int P d\theta} = (V_o + W\theta)\, e^{\alpha\theta}$$

$$\int e^{\int P d\theta} Q d\theta = \frac{W(t_w - t_s)}{\alpha} e^{\alpha\theta}$$

Thus, the equation for the standard solution is

$$T = t_s - \frac{(t_s - t_w)}{\alpha}\left(\frac{W}{V_o + W\theta}\right) + \frac{ke^{-\alpha\theta}}{V_o + W\theta}$$

However, $\alpha = 0.8\,U/c_p\rho = (0.8)\,(300)/(1)\,(62.4)\,(60) = 0.0641$. Note inclusion of the factor 60, since time is in minutes.

Substituting the known values, we get

$$T = 212 - \left(\frac{212 - 50}{0.0641}\right)\left(\frac{1}{10 + \theta}\right) + \frac{ke^{-0.0641\theta}}{10 + \theta} \qquad (26)$$

When $\theta = 0$, $T = 212$ F., the value of $k = 2{,}527$ and Eq. (26) reduces to

$$T = 212 - \left(\frac{2{,}527}{10 + \theta}\right)(1 - e^{-0.0641\theta}) \qquad (27)$$

Again we check the reliability of our equation. when $\theta = 0$, $T = 212$ F. which is a known boundary value. As θ increases, the temperature approaches 212 F. This is reasonable since we add fresh water at 50 F. at a constant rate. The added water requires a certain rate of heat input to bring it up to 212 F.

However, the area through which heat can be transferred increases continually. The rate of heat input could then increase without bound. Therefore the driving force decreases or the temperature of the water increases.

We have calculated values for different flow rates of water into the system. As expected, we find that the higher the input rate, the further the curves fall before they again start to rise.

Some values where $W = 1$ and $W = 5$ are tabulated here and plotted in Fig. 1.

It is interesting to note that we can rewrite the equation to express unaccomplished temperature change as was done in *Problem* 2.

$$\frac{t_s - T}{t_s - t_w} = \frac{W}{\alpha\,(V_o + W\,\theta)}\,(1 - e^{-\alpha\theta}) \qquad (28)$$

In this case, if we replace 212 F. with 0 and 50 F. with 1 in Fig. 1, we have a plot of the unaccomplished temperature change vs. time.

Problem 5—A chemical compound A reacts irreversibly to form B. The reactions takes place in a well-stirred catalytic tank of volume V. Fresh feed of composition c_i is fed to the tank at rate W. Liquid with composition c_A is removed from the tank also at rate W.

At any time the composition within the tank is also c_A. The rate at which A is converted to B within the tank is proportional to the concentration of A. The reaction rate constant is k. Units are c_i and c_A = compound A, lb.-mol./cu. ft.; W = rate, cfm. and V = tank volume, cu. ft.

Derive and solve the differential equation for the concentration of A in the tank as a function of time, θ.

Solution—A diagram is shown in Fig. 2. Our differential equation results from a material balance on component A. From the word equation, "rate of input minus rate of output equals rate of accumulation," we get

Input = $Wc_i d\,\theta$ during time $d\theta$.
Output = $Wc_A d\theta + kVc_A d\theta$.
Accumulation = $[d(Vc_A)/d\,\theta]\,d\,\theta = Vdc_A$.

Note that we have included the amount of A reacted as an output. Also units are consistent.

The equation for the material balance is now

$$Wc_i d\,\theta - Wc_A d\,\theta - kVc_A d\,\theta = Vdc_A \qquad (29)$$

Rearranging Eq. (29) yields

$$\frac{dc_A}{d\,\theta} + \left(\frac{W}{V} + k\right)c_A = \left(\frac{W}{V}\right)c_i \qquad (30)$$

To see what Eq. (30) means, let us explore some simple solutions. It is a linear equation but the possible solutions will vary depending on the nature of c_i. Note that when no reaction takes place $k = 0$. We then have the equation for an ordinary first order dilution problem.

We will assign some numerical values to obtain graphs which illustrate the various solutions. In the units given above, assume $V = 10$, $W = 1$ and $k = 0.2$.

$k = 0$,
a dilution problem.

General Equation

$$\frac{dc_A}{d\,\theta} + 0.1c_A = 0.1c_i$$

Steady State Case,
$c_i = 1$.

$$\frac{dc_A}{d\,\theta} = 0. \quad c_A = c_i = 1$$

Step Function,
$c_i = 1$ and $\theta < 0$
$c_A = Ae^{-0.1\,\theta} + c_i$
$\theta = 0$, $c_A = c_{Ao} = A + c_i$
$A = 1 - 3 = -2$
$c_A = 3 - 2e^{-0.1\theta}$, $\theta \geq 0$

$k = 0.2$,
a kinetic problem.

General Equation

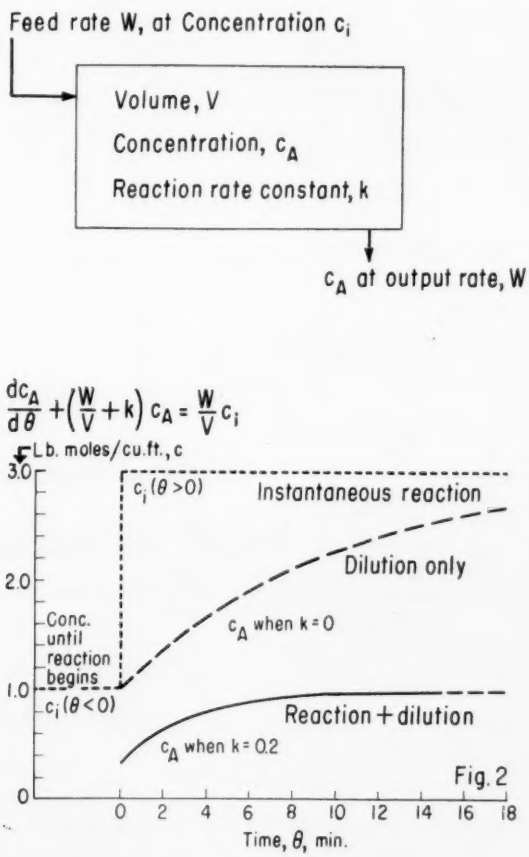
$$\frac{dc_A}{d\,\theta} + 0.3c_A = 0.1c_i$$

Steady State Case,
$c_i = 1$.

$$\frac{dc_A}{d\,\theta} = 0. \quad c_A = c_i/3 = 0.333$$

Step Function
$c_i = 3$ and $\theta \geq 0$
$c_A = Ae^{-0.3\theta} + c_i/3$
$\theta = 0$, $c_A = c_{Ao} = A + c_i/3$
$A = 0.333 - 1 = -0.667$
$c_A = 1 - 0.667e^{-0.3\,\theta}$, $\theta \geq 0$

Curves for these solutions are shown in Fig. 2.



Formulas for Suspensions and Solids

Maxey Brooke, Chemical Engineer, Sweeny, Tex.
(Meet your author on p. 166).

48. Friction Factor for Sludge/Friction Factor of Water

APPLICATION

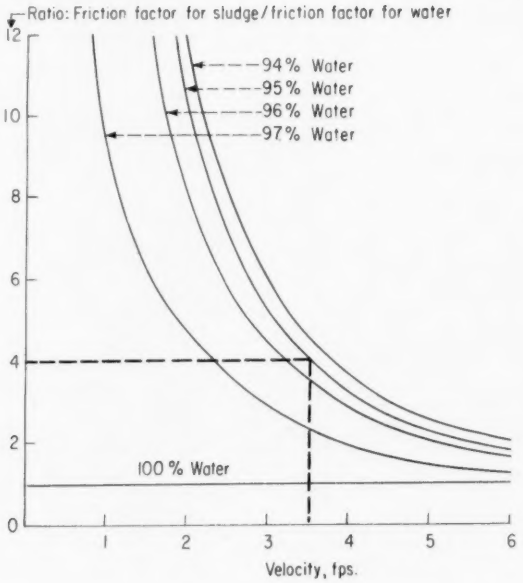
Flow of primary sewage sludge in four to six in. pipes.

EXAMPLE

If the friction loss for water at 3.5 fps. is 0.058, then the friction loss for sludge containing 95% water is 0.058 × 4 = 0.232.

REFERENCE

"Bulletin 261," American Well Works Co., Inc., Aurora, Ill.



49. Non-Fluidized Flow of Granular Solids

FORMULA[1]

$$F = 8.50D^{2.06}H^{0.04}$$

SIMPLIFIED FORMULA[2]

$$F = 16.17D^{2.5}$$

REFERENCES

1. R. H. Newton, G. S. Dunham and T. P. Simpson, *Trans. AIChE*, **41**, 215–32 (1945).
2. S. A. Gregory, *J. Appl. Chem.*, **2**, Suppl. 1 (1952).

NOMENCLATURE

- D Conduit diameter, in.
- F Flow, lb./min.
- H Head, ft.

50. Flow of Oil-Coal Suspensions Through Pipe

FORMULA

$$\frac{H}{L} = \frac{V\mu}{D^2\rho}\left[\frac{K}{K-C}\right]$$

LIMITATION

Concentrations under 30% coal.

REFERENCE

Gradishar, Faith and Hedrick, *Trans. AIChE*, 39 201–22 (1943).

NOMENCLATURE

- C Coal in suspension, % by volume.
- D Pipe diameter, ft.
- H Pressure drop, ft. of flowing mixture.
- K Constant = 40.0 for 100 mesh coal, 38.4 for 200 mesh coal and 37.5 for 350 mesh coal.
- L Pipe length, ft.
- V Velocity, fps.
- μ Viscosity, lb./sec.-ft.
- ρ Density, lb./cu. ft.

These Stainless Steel bran shakers won't corrode, and they'll last years longer than equipment made of other, less durable materials. Beçause Stainless Steel is so strong, the new units at Staley's can be made thinner and lighter than comparable equipment made from other materials.

Sulfur dioxide doesn't harm Stainless Steel

at A. E. Staley Manufacturing Company, Decatur, Illinois

Staley's grinds and processes more than 60,000 bushels of corn daily in a continuous-flow operation that demands unfailing performance from every piece of equipment along the line.

And the equipment must be clean, for this corn is made into foods and nutrients. Corn starch, oil and syrup for the food industry must not only be chemically pure, but must be produced with food-grade cleanliness.

That's why company officials, constantly alert for any possible improvement or avoidance of trouble or contamination, were so pleased to find that Stainless Steel solved their sulfur dioxide corrosion problems. Previously the best selection of piping did show corrosion and the sulfur dioxide even attacked tanks of nonmetallic material causing porosity, cracks and corroded equipment. This increased both maintenance and control costs in producing satisfactory products.

Staley's standards called for pipes and tanks that would stay smooth and clean, impervious to the sulfur dioxide. That's why they replaced the outmoded piping and tanks with Stainless Steel.

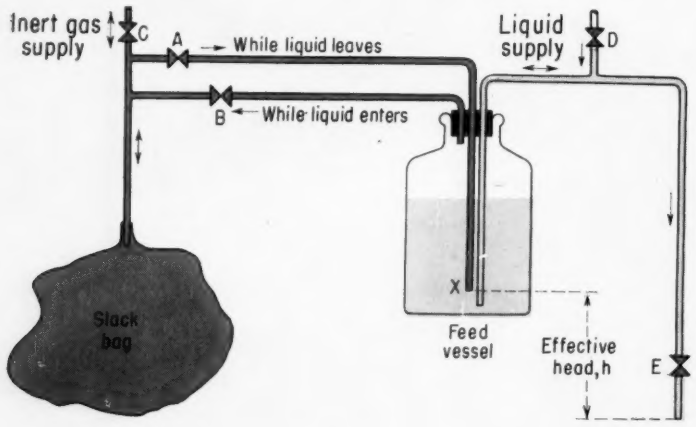
"Stainless is *the* material for us," says Mills L. Calvert, Staley senior project engineer. "With stainless piping and tanks, I don't have to worry about corrosion or breakdown."

When you replace equipment in your plant, think about strong, corrosion-resistant Stainless Steel. And if you want service-tested quality, specify USS Stainless Steel. For fast delivery, call your local steel distributor.

USS

USS STAINLESS STEEL

UNITED STATES STEEL



Air-Excluding Constant Feeder

Where an air-sensitive chemical must be fed at a constant rate, a simple idea permits inert gas to be used.

★November Contest Winner by
Thomas J. Dixon

Chemical Engineer, Callery Chemical Co., Callery, Pa.

In laboratory, pilot plant and small batch operations it is often necessary to maintain a small constant flow of some chemical or petroleum fraction which should not be allowed to contact air. The scheme shown here is an adaptation of an old constant-head feeding idea to the use of an inert gas atmosphere.

The feeder vessel may be glass or metal, depending on the scale of the operation. It is piped up as shown, with a slack bag of flexible impervious material, e.g., rubber, vinyl beach ball or polyethylene "freezer bag." The tubing may be glass and rubber, with pinch cocks; or metal piping with valves can be used. Valves *A* and *B* may be check valves to simplify operation.

To use the system, first purge it with inert gas admitted through *C*. Then admit liquid through *D*, after first closing *A*, *B* and *C*. Valve *E* is opened long enough to fill the line to *E*, then closed and *B* opened, allowing the feed vessel to fill by displacing inert gas back into the slack bag. Any excess gas can then be vented through *C*. Flow is then started by closing *B* and opening *E* and *A*. The effective head *h* will determine delivery rate and will remain constant until level drops to Point *x*.

This arrangement has the advantage of easy recharging without replenishing the blanket gas. Valve manipulation during recharging is just the same as in the original charging.

Motor Capacitors Can Be Rejuvenated

Paul C. Ziemke
Engineer, Clinton, Tenn.

Small single-phase motors are often of the capacitor-start type, with an electrolytic condenser. If used in hot areas, there is sometimes a slow drying out of the electrolyte which calls for replacement of the condenser.

We thought it might be possible to replace the lost moisture and rejuvenate the old condenser, saving down time as well as replacement cost and labor. So, when an 82-mf. condenser on a mixer drive failed from drying, we drilled a neat ¼-in. hole through the casing, taking care not to clip the aluminum foil inside, then injected enough distilled water to fill the void left by the drying.

Finally, the opening was sealed by sweating on a small patch with solder and a soldering iron. Result: a renewed condenser.

Did You Miss Last Issue's Announcement?

Starting with the April 7 issue, a new department to be called the Design Notebook will alternate with the Plant Notebook. This department solicits short articles primarily of interest to engineers in engineering research and development, and in process, plant and equipment design.

All articles submitted for either the Design Notebook or the Plant Notebook will be considered at the end of each four-week period for a single $50 prize. In any such period a winner will be selected from either the Design or the Plant area and will be published in the appropriate department.

Articles received during February 1958 and later will be judged for both departments. For contest rules see p 144.

2,333,333-gallon CB&I-Built Aluminum Tank . . .

stores 83% ammonium nitrate

It's the world's largest all-aluminum tank. 120 ft. in diam. by 26 ft. high and constructed of more than 300,000 lbs. of aluminum, it was fabricated and erected by Chicago Bridge & Iron Company for the Mississippi River Chemical Company at Selma, Missouri. Providing storage for 2½ million gallons of 83% ammonium nitrate, it provides Mississippi River Chemical Company uninterrupted storage service with a minimum of maintenance.

Chicago Bridge & Iron Company has complete facilities at four plants to design, fabricate and erect special and standard plate structures of steel or other special metals to meet your most rigid specifications.

When *you* plan structures, write our nearest office . . . *and plan with CB&I.*

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • South Pasadena • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY, GREENVILLE, PA. and NEW CASTLE, DEL.

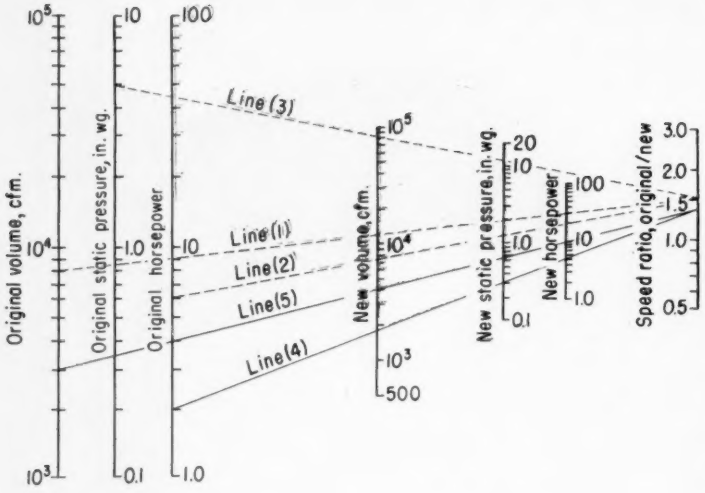


Chart Selects Centrifugal Fans

Edward J. Gibbons
Mechanical Engineer, New York, N. Y.

It is often necessary to modify the performance of a centrifugal fan to meet new operating conditions or possibly to correct for design deficiencies.

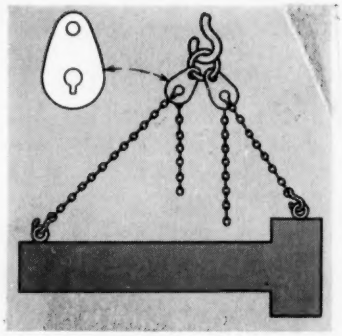
The chart above is based on the universal fan laws and relates the three interdependent variables of volume discharge, static pressure of output, and horsepower required. It also ties in a fourth variable, speed ratio.

Drawing a line between the initial and final condition of any of the variables determines the speed ratio which can be used as a pivot point to find the change in other variables from initial to final condition. For example, if we want to boost output of a fan from 8,000 cfm. to 12,000 cfm., volume line (1) shows that a speed ratio of 1.5 is needed.

Using this speed ratio as a pivot we find that if the fan originally took 6 hp., it will take 20 at the higher speed (Line 2). If initial static pressure produced by the duct resistance was 5 in. w.g., the new static pressure will be 11¼ in. (Line 3). Volume-pressure characteristics of duct systems vary the same as the speed-pressure characteristics of fans.

Since the speed ratio is 1.5, if the motor speed was initially 1,140 rpm., then the fan speed for the new conditions will be 1,140 × 1.5 or 1,710 rpm.

Another way the chart can be used is to find the capability of a fan with an underloaded motor. If the fan is drawing 2 out of the available 5 hp. of the motor (Line 4), then with an increase of 35% in speed the volume can be increased (Line 5) from an initial 3,000 cfm. to about 4,000 cfm. Many such problems are quickly solved with the chart.



Heavy Handling Trick For Plant Shops

Buckley Sullivan
Engineer, Cleveland, Ohio.

In the plant shop or salvage yard it is often necessary to handle heavy, non-symmetrical loads suspended by chains from the crane hook. Since chains of different lengths are needed to bring the center of gravity under the hook, there is often considerable fumbling and lost time in trying to find chains of the right length.

We found a simple solution to this dilemma. We cut a pair of slotted plates as in the sketch from heavy stock, joining them with a welded ring for the crane hook. Any number of links of the chain can be pulled through the hole in the plate and caught in the slot. Balancing the load is easy and the length of chain is unimportant; 15-ft. lengths now serve for almost all jobs.

NEXT ISSUE: Sampler for Particles in Wet Gas Streams
BY JESS W. THOMAS, WINNER OF THE DECEMBER CONTEST

*How Readers Can Win

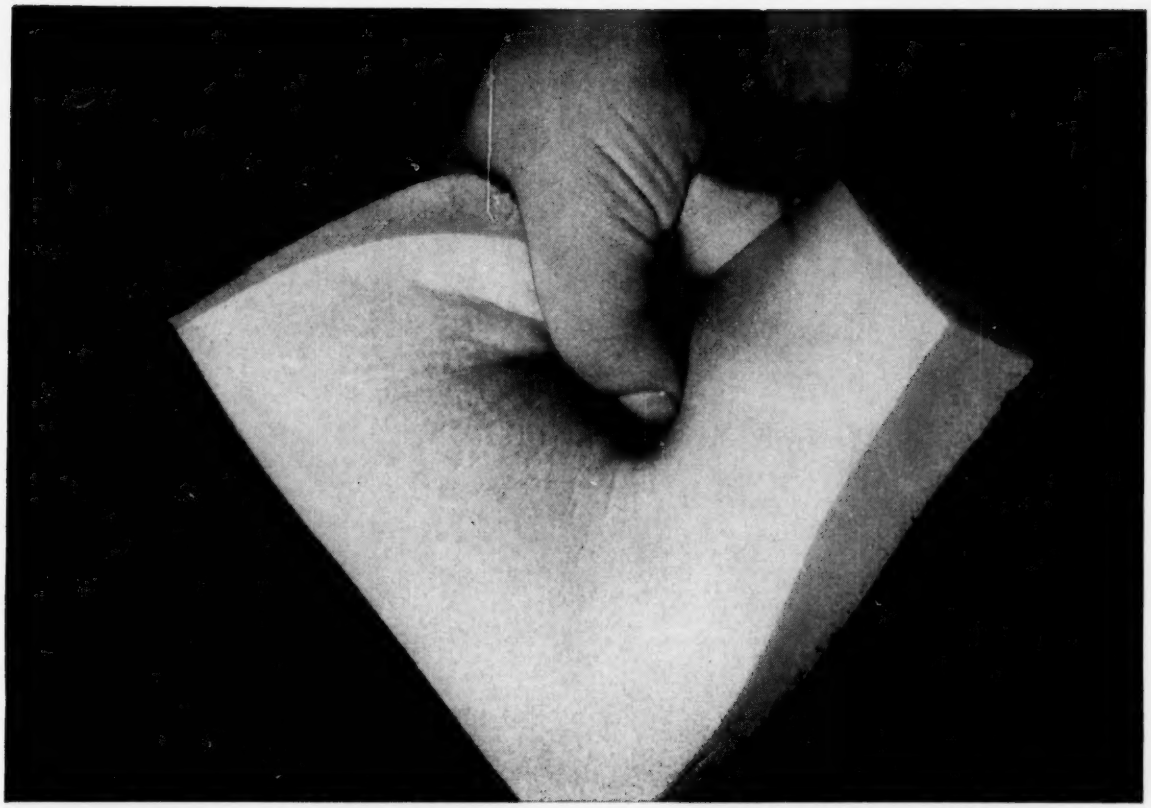
$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Design Notebook.

Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable non-winning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Design Notebooks, *Chemical Engineering*, 330 W. 42nd St., New York 36, N. Y.



Good compression—is one advantage of polyether-based polyurethane foams made from new NIAX Diol PPG 2025. In addition, it helps give foams that are lower in cost than other types of flexible foams.

Now—Lowest cost Polyurethane Foams

from NIAX Diol PPG 2025

TRADE-MARK

(POLYPROPYLENE GLYCOL 2025—RESIN GRADE)

Lowest cost you say? Right! Polyether-based foams, from NIAX Diol PPG 2025 are lower in cost than other types of flexible foams. Therefore, if you are making prepolymer or foam, you'll want to take advantage of NIAX Diol PPG 2025. This new material assures uniform properties of the prepolymer or foam—from batch to batch.

In addition to imparting good compression—deflection characteristics, resilience, and recovery properties, field tests show NIAX Diol PPG 2025 gives the added advantage of excellent humid-aging.

Union Carbide Chemicals Company's NIAX Diols PPG 425, 1025, and 2025 also are bases for other types of flexible and rigid urethane foams.

For samples and specification data on these products, write Union Carbide Chemicals Company, Room 328, Department H, 30 East 42nd Street, New York 17, New York.

In Canada: Carbide Chemicals Company, Division of Union Carbide Canada Limited, Montreal.

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CHEMICALS

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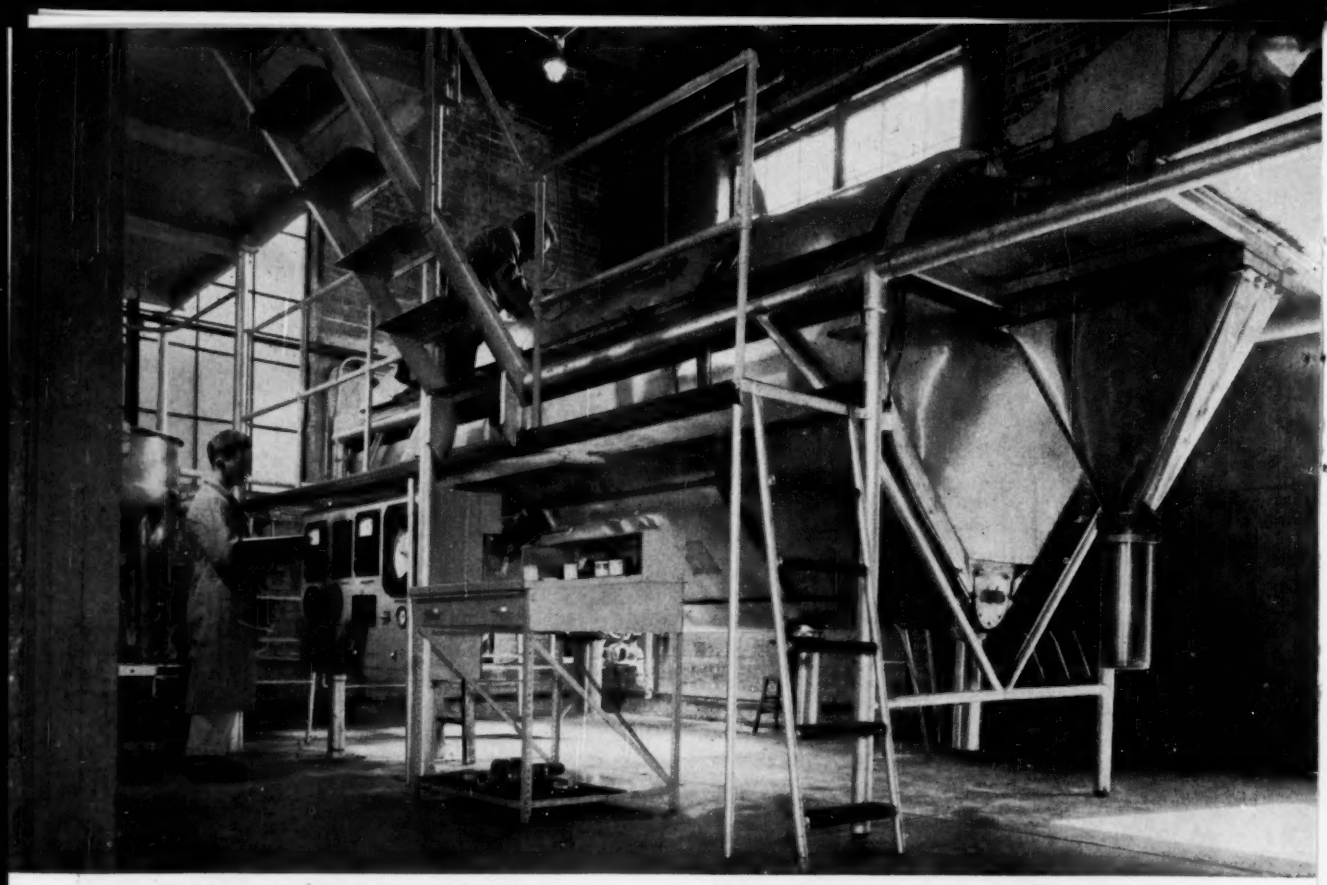


RUNNING SPRAY DRYING TEST IN BUFLOVAK'S PROCESSING LAB. The lab contains a complete line of small scale and pilot size processing equipment for investigating drying, evaporation, extraction, impregnation, crystallization, and other processes. Here you can test a few beakers of material or run tank car quantities on a full time production scale.

Buflovak Spray Dryers—new horizontal high velocity design for instant drying... improved products...lower operating costs

Whether it's food or chemicals, Buflovak flash drying gives products new, more marketable characteristics.

Buflovak Horizontal Spray Dryers convert a liquid to a dry product instantaneously. Short exposure to heat helps to retain all the desirable product characteristics. Particle size and shape can be selected and controlled. The finished product is continuously removed and discharged from one point.

Compactly designed, these dryers require little headroom, keep initial and operating costs low. Complete accessibility makes between-batch cleaning easy and economical. Buflovak Spray Dryers offer a choice of high efficiency powder collecting systems best suited to your product.

Test your product in the Buflovak customer service laboratory

It's easy to check your product by running a test in the lab spray dryer. Here you can work with skilled engineers to obtain accurate performance data and actual samples of your spray dried product . . . see particle characteristics . . . examine process efficiency.

Contact Buflovak's research department for details on the facilities and services available to you.

BLAW-KNOX

BLAW-KNOX COMPANY
Buflovak Equipment Division
1551 Fillmore Avenue, Buffalo 11, N.Y.

Using Salt Efficiently

by INTERNATIONAL SALT COMPANY, INC.

Hydraulic Handling—Quick, Economical Way to Move Salt into Storage

Here's a new, effective method for moving salt from delivery cars or trucks into plant storage, without disrupting other operations. Hydraulic Handling systems, already in operation in several plants, have eliminated the expense of mechanical unloading equipment, and cut down considerably on man-hours needed to do the job.

What is Hydraulic Handling? Very simply, Hydraulic Handling is the movement of granular salt in circulating saturated brine, through pipes. Referring to the diagram, you will note that dry salt from the hopper car is mixed with saturated brine in a salt-receiving pit, to form a slurry of the saturated brine and undissolved salt. This slurry is pumped through a pipe to a salt-storage tank. Overflow brine from the tank continuously returns to the slurrying pit to carry more salt into storage.

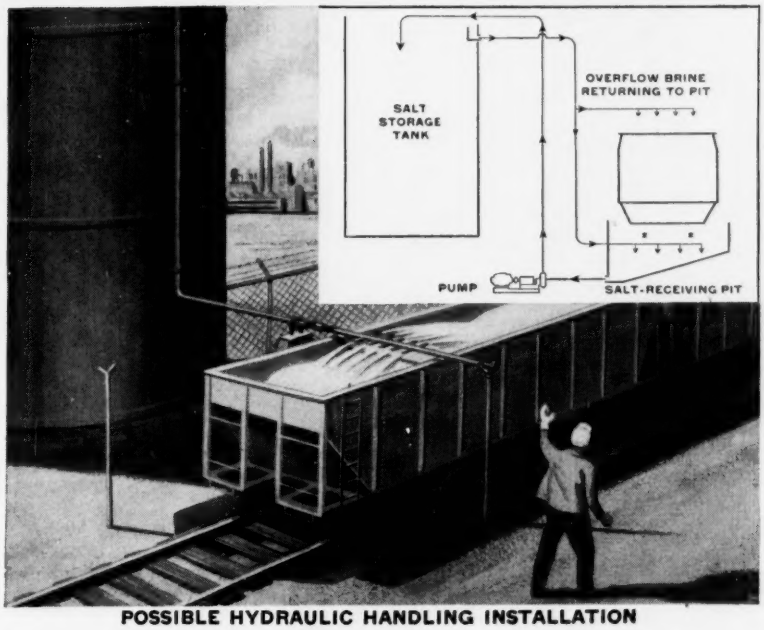
Advantages of Hydraulic Handling. Every Hydraulic Handling installation has a number of exclusive advantages:

1. Great flexibility. Because *pipes* do the work of carrying salt, a Hydraulic Handling system can be installed anywhere in the plant. Piping is flexible, and can be run where it won't interfere with other plant operating activities.

2. No need to move existing equipment. Machines that might obstruct mechanical handling equipment simply don't get in the way of a Hydraulic Handling installation.

3. Long life, low maintenance. You need no safety guards . . . no roofing to protect salt from weather . . . no belt conveyors, elevators or similar pieces of mechanical handling equipment. Also, there is never any salt dust that might corrode vital plant equipment. As a result, Hydraulic Handling installations have a long life, with very little maintenance expense.

4. Unlimited capacity. Hydraulic Handling systems can be designed to unload, move and store any amount and type of salt—rock or evaporated. Whatever your specific unloading needs, Hydraulic Handling can satisfy them.



POSSIBLE HYDRAULIC HANDLING INSTALLATION

For rock-salt users, Hydraulic Handling is especially economical when used with combined wet-storage and dissolving tanks or with International Salt Company's famous Sterling Wet-Storage Lixator. These units store Sterling Rock Salt the same way Hydraulic Handling moves it: combined with saturated brine. Thus the salt-and-brine slurry delivered through Hydraulic Handling to the Lixator *is already in the correct form.* The Lixator delivers 100%-saturated Lixate Brine through pipes to any point of use in the plant, and automatically makes more brine as needed.

From delivery to use, dry rock salt is never handled in plants equipped with both a Hydraulic Handling system and a Sterling Lixator.

You can get more information on how Hydraulic Handling can work in your plant to cut down salt-unloading and salt-handling expense from International Salt Company. One of our experienced Sales Engineers will be glad to work with you to determine the best system of Hydraulic Handling for your specific needs. He can also help you use salt efficiently in *all* your plant operations needing salt or brine.

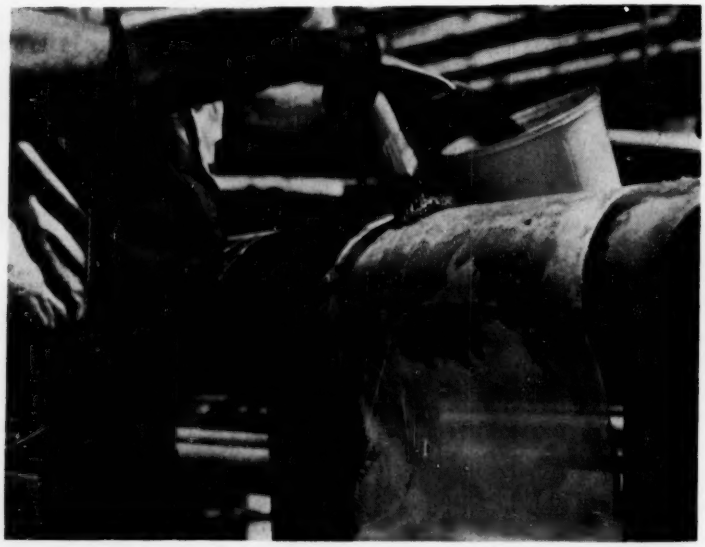
Behind this qualified salt specialist are all the resources and experience of International Salt Company. We produce both Sterling Rock Salt and Sterling Evaporated Salt in all types and sizes . . . plus automatic equipment for making brine from both kinds of salt. So our sales engineer can recommend the type and size of salt most perfectly suited to your needs. He can also recommend the most efficient and inexpensive methods for storing, handling or using salt or brine. Ask him . . . send a card or letter to International Salt Company, Inc., Scranton 2, Pa. . . . or contact our nearest sales office.

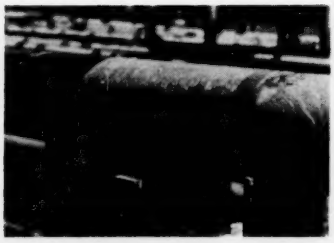
INTERNATIONAL SALT CO., SCRANTON, PA.

Sales Offices: Atlanta, Ga.; Chicago, Ill.; New Orleans, La.; Baltimore, Md.; Boston, Mass.; Detroit, Mich.; St. Louis, Mo.; Newark, N. J.; Buffalo, N. Y.; New York, N. Y.; Cincinnati, O.; Cleveland, O.; Philadelphia, Pa.; Pittsburgh, Pa.; Memphis, Tenn; and Richmond, Va.

Service and Research are the Extras in **STERLING SALT**

PRODUCT OF INTERNATIONAL SALT COMPANY, INC.





RUPTURED PIPE is wrapped with layers of epoxy-impregnated glass cloth; back in service after a few hours. Method safer than welding.

Build or Repair With Epoxy-Glass Laminates

- **Fast patch for corroded process equipment.**
- **Up-and-coming resistant construction material.**

T. G. Nock and R. A. Coderre, Shell Chemical Corp., New York*

Glass-reinforced laminates based on epoxy resins are now recognized as engineering materials of wide potential use in the chemical process industries. Laminates of this type are strong, light, resistant to a variety of chemicals and possess a number of advantages over thermoplastic materials.

Epoxy laminates are now used in the fabrication of equipment for chemical service such as tanks, pipe, fume hoods, ducts and exhaust stacks. And, in an unusual new technique, the basic materials—epoxy resin and glass cloth—can also be used for preparing durable patches for process metal pipe, tanks and pressure vessels.

Fast and reliable repairs can be made in localized areas where corrosion has caused failure. For example, use of resin kits for such repairs was found to reduce plant down time and manpower requirements at Shell Chemical Corp.'s plants, where a thorough evaluation of these patch repairs was started in 1955.

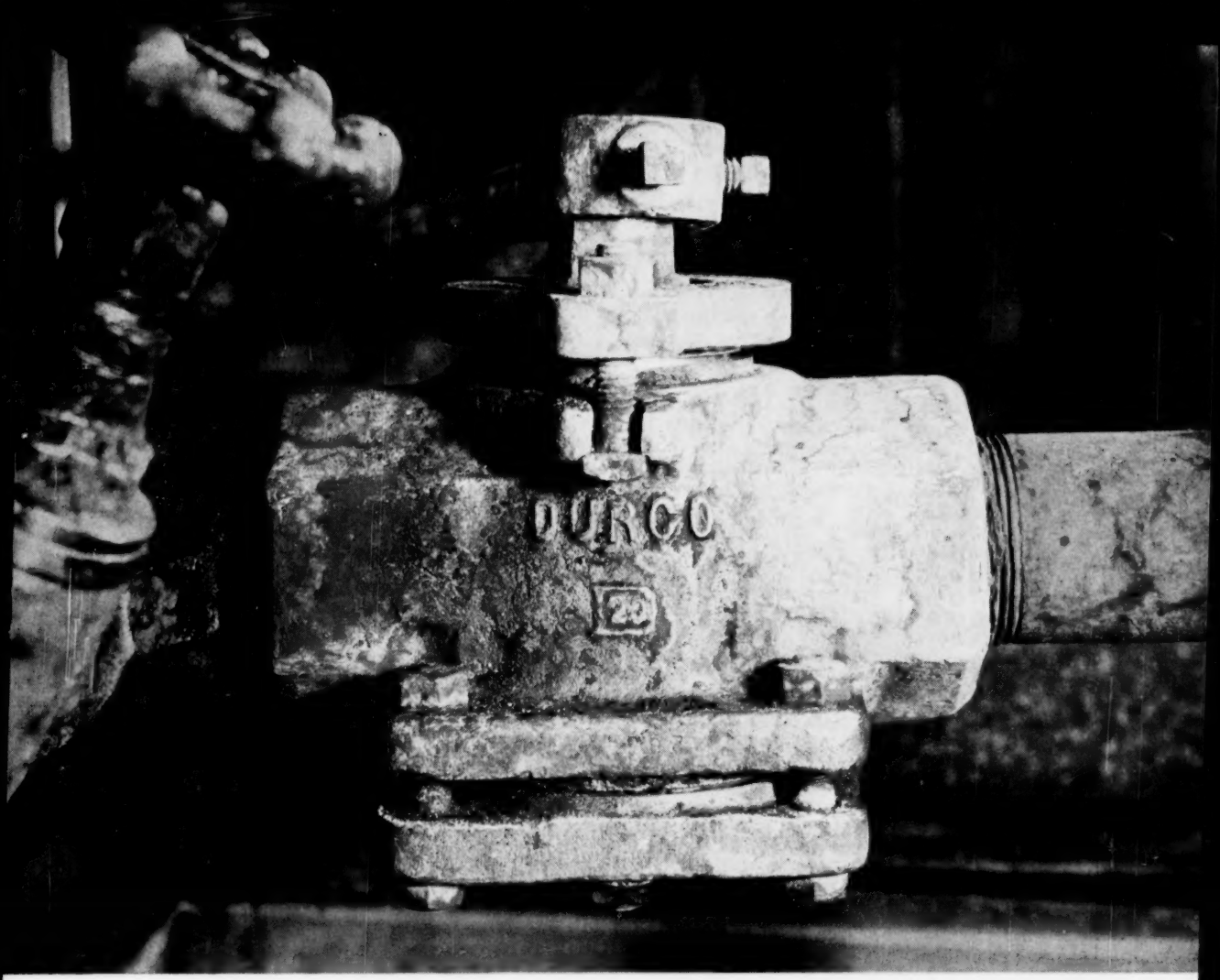
▶What Are Epoxy Laminates? — Epoxy-resin laminates are thermoset materials which may be used at temperatures up to about 250 F. Glass cloth is the common reinforcing agent, although nylon and Orlon can be used for special chemically resistant laminates. Because of the extremely high bonding strength of epoxy resins, glass-reinforced epoxy laminates are mechanically among the strongest plastics materials known. When properly cured, they show excellent resistance to non-oxidizing acids, such as hydrochloric, phosphoric and dilute sulfuric acids, as well as alkalis and organic compounds.

The outstanding properties of epoxy laminates as engineering materials are made possible by certain characteristics of the resins themselves. These include: good chemical resistance, especially to water, in the cured condition; low shrinkage during cure (minimum of strain in cured product); high heat distortion temperature; ability to develop adhesive bond with many materials; ability to cure (or harden) without applying heat.

Epoxy laminates used in the chemical industry are of two general types, which may be classified as "general purpose" and "heat resistant." The main difference between these materials is the nature of the amine curing agent used in hardening.

General purpose laminates incorporate aliphatic polyamines, such as diethylenetriamine,

* Meet your authors on p. 165 and p. 168.



Absolutely no maintenance costs in four years of tough chemical service

This DURCO type F valve on the bottom outlet of an arsenic acid recovery tank has served Abbott Laboratories for four years with absolutely no maintenance: dependable service that is hard to beat.

DURCO type F valves with renewable Teflon sleeves are available in sizes from ¼" thru 3" in stainless steel and a wide range of corrosion resisting alloys. These DURCO valves have proved their reliability in tough chemical services in thousands of applications since 1950.

For dependability, insist upon DURCO. The DURCO type F valve will not stick or gall, requires no lubrication, has reverse-taper plug and simple adjustment to insure positive shut-off.

Abbott Laboratories is one of the world's leading manufacturers of pharmaceutical products. For nearly 70 years Abbott has been devoted to serving mankind through the preparation of standardized, dependable drugs including anesthetics, antibiotics, radio-pharmaceuticals, and nutritional products.

DURCO TYPE F VALVES

a product of

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

THE DURIRON COMPANY, INC., Dayton 1, Ohio

BRANCH OFFICES: Baltimore, Boston, Buffalo, Chicago, Cleveland, Detroit, Houston, Knoxville, Los Angeles, New York, Pensacola, Fla., Philadelphia, and Pittsburgh

Epoxy Characteristics Produce Superior Laminates

- Good chemical resistance in cured condition (especially to water).
- Low shrinkage during cure and minimum strain in cured product.
- High heat distortion temperature.
- Ability to develop adhesive bond with many materials.
- Ability to cure (or harden) without applying heat.

which harden epoxy resins at room temperature. Epoxy systems of this type are used in the patch repairs. Excellent laminates are obtained. However, their heat resistance and chemical resistance are not as good as with other curing systems.

The heat resistant type of laminate is commonly cured with a heat-activated aromatic amine curing agent, such as metaphenylenediamine. Such laminates offer the optimum in chemical resistance and strength at elevated temperatures. Heat resistant laminates are commonly used for fabricated plastic equipment, such as pipe, tanks, fume hoods and exhaust stacks (see table of important properties).

▶ **Glass-Epoxy Patches**—Repair kits of epoxy resin and glass were developed originally for automobile body repair. The Chevrolet division of General Motors, for example, has listed them in their parts catalogue for several years. Patch kits developed for industrial plant use are now available from Industrial Waterproofing Co., Houston, Tex.; Co-Polymer Chemicals, Livonia, Mich., and Bonded Products, Inc., Chicago, Ill.

Resin patch kits have seldom been used in chemical plants for permanent repairs. They are primarily intended for temporary or emergency repairs which will permit normal operations until a replacement can be obtained or until permanent repairs are possible.

The usual alternative repair method, welding, requires that process equipment be made gas-free to avoid the danger of fire or explosion. Epoxy-resin glass-cloth repairs may be applied even though flammable vapors are present. Further, expoxy-resin patches may be used successfully where equipment size or wall thickness precludes the use of resilient pads with conventional clamps or bands over corroded areas.

In using the epoxy-resin, glass-cloth patches, several layers of glass cloth are cemented to the metal surface to be repaired. Curing agents adaptable to curing the resin at room temperature are used. Glass cloth provides necessary tensile strength; the resin adheres to the metal and seals the cloth.

Liquid resins used have a viscosity low enough to permit easy flow and thorough saturation of the glass cloth. The resin cures rapidly, becoming hard within two hours (at 70-80 F.) and reaching a complete cure in about six hours. No clamps or pads are required for support either during or after cure. Down time for the complete repair may be 10 hours or less.

Excellent adhesion of the resin makes possible repair of leaks in large equipment, such as tanks, and on thin-walled pipe and vessels which would be crushed by clamps. When repairing tanks, it's not necessary to make the area vapor-free, although the liquid level must be lowered to keep the metal surface clean and dry while the patch is being applied.

Experience has shown that the pressure which can be contained by a patch-type repair depends on the size of the hole, number of plies of glass cloth and the amount of overlap on sound metal. However, repairs which are to withstand any but the slightest pressures should not be attempted if the patch cannot extend at least two inches beyond the leak. Repairs to piping will withstand considerable pressure if the cloth is wrapped completely around the pipe.

▶ **Not for High Temperatures**—Some limitations of the epoxy resin-glass cloth repair scheme are: patches should not be applied where operating temperatures will exceed 250 F.; the resin will resist only moderately strong acids.

Surface of the metal must be well cleaned before resin is applied, and at least six hours must be allowed for the resin to cure. However, curing time is usually considerably shorter than the preparation time which would be required for welded repairs.

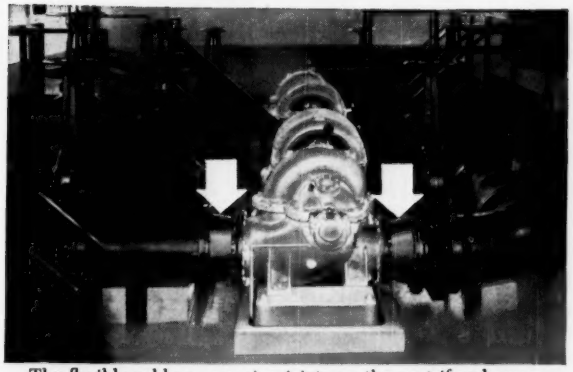
Successful patches of epoxy resin and glass cloth have been made at Shell Oil and Shell Chemical plants to piping, product storage tanks, distillation columns, walls of pressure vessels, metal fume ducts and to feed nozzles of heat exchangers and stripping units.

Important Properties of Epoxy Resin Laminates

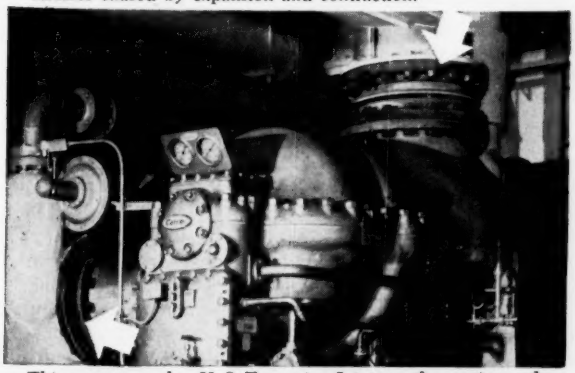
	General Purpose Type	Heat Resistant Type
Resin content	44%	32%
Specific gravity	1.56	1.63
Flexural strength (ASTM D79E-49T)		
Ultimate stress	40,000 psi.	83,000 psi.
Modulus	2.1×10^6 psi.	3.2×10^6 psi.
Tensile strength (ASTM D638-52T)		
Yield stress	————	54,000 psi.
Modulus	————	3.5×10^6 psi.
Coefficient of linear thermal expansion (ASTM D696-44)	30×10^{-6} in./in./°F.	27×10^{-6} in./in./°F.
Max. recommended continuous service temp	80 C. (176 F.)	145 C. (294 F.)

EXPANSION JOINTS

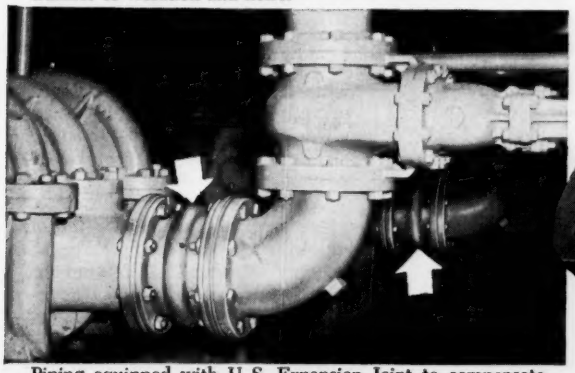
Expanding the Designer's Scope



The flexible rubber expansion joints on the centrifugal pump installations (above) are made by U. S. Rubber. They prevent stresses caused by expansion and contraction.



This compressor has U. S. Expansion Joints on the suction and discharge lines. Like all U. S. Joints, these insulate against the transfer of vibration and noise.



Piping equipped with U. S. Expansion Joint to compensate for any misalignment caused by load stresses, wearing of parts or settling of building.

U. S. Rubber Expansion Joints are resilient and therefore do not, like metal, set permanently when compressed. Constant flexing merely keeps them alive... prevents brittleness.

- They absorb both axial and lateral deflection far more than metal joints. Greater insulation against vibration and pump noises. No electrolysis, corrosion or erosion.
- Handle pressures from 40 lbs. to 125 lbs.
- The outside diameter of the arch is smaller than on metal joints. (Face-to-face dimensions, even with multiple arches, are smaller.)
- Weight is much less. This, plus the fact that no gasket is needed between flanges (metal joints require gaskets) results in an easier installation lowering the cost.

"U. S." was the *first* to develop expansion joints. They are at work in every kind of industry, prolonging the life of equipment in pressure or vacuum pipe systems. Some are still in service, after 30 years of operation. Obtainable at any of the 28 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

For the complete technical information catalogue on the entire line of U. S. Rubber Expansion Joints, contact your nearest "U.S." District Sales Office or write us at Rockefeller Center, New York 20, New York.

Mechanical Goods Division

United States Rubber

Typical Properties 3½ in. O.D. Pipe*

Wall thickness, in.	0.15	0.24
Weight/ft.	1.07 lb.	2.05 lb.
Rated operating press., 220 F.	200 psi.	500 psi.
Rated collapse press., 125 F.	50 psi.	350 psi.
Hoop tension at burst	25,800 psi.	24,500 psi.

*Epoxy-glass laminate, Fibercast Corp.

► **Also Plastic Pipe**—Laminated epoxy resin pipe is now available for chemical plant and oil field use. Pipe of this type, for example, has shown excellent durability in handling salt water in oil field service at 1,000 psi. and 120 F.

In chemical processing, pipe has proved adequate for handling moderately strong acid solutions (such as 75% phosphoric) at temperatures up to 200 F.

Epoxy pipe is more expensive than steel pipe, but it lasts much longer in service involving the handling of salt water, sour crude oil, dilute acids and caustic solutions. However, it is not recommended for handling active organic solvents, such as chlorinated hydrocarbons.

Epoxy resin pipe has been developed for applications where thermoplastic pipe is not suitable—those involving service pressures above 100 psi. and service temperatures up to 200 F. Laminated epoxy pipe is stronger than extruded pipe now available; demonstrates longer useful life in severe chemical service; and gives better performance at elevated temperatures.

Commercial pipe is now available from the Fibercast division, Youngstown Sheet and Tube Corp., Sand Springs, Okla., in 2⅜ in., 2⅞ in. and 3½ in. sizes (O.D.). Both line pipe and well tubing are sold, with either threaded or bonded fittings. Other firms which have epoxy pipe under development are Minnesota Mining and Manufacturing, Amercoat, A. O. Smith Corp., and Food Machinery and Chemical Corp.

► **And Tanks**—Laminated epoxy resin tanks having capacities up to 500 bbl. are now commercially available from the National Tank Corp., Sand Springs, Okla., and the Haveg Corp., Marshalltown, Del. These tanks are strong, light in weight and retain their strength.

Novel Mobile Coating For Chemical Equipment

Dozens of so-called novel, corrosion-resistant coatings come on the market every day—few are really novel and some are not resistant to corrosion. But a coating now undergoing intensive tests in chemical plants appears to merit those adjectives: a soft, gel-like material developed by Eureka Chemical, San Francisco, Calif.

Eureka claims their coating can be easily applied directly over rusted surfaces, providing a continuous, mobile film for excluding oxygen and moisture. The film is tenacious, stable, doesn't evaporate and is not water soluble. Mobility is a major advantage—rigid coatings are seldom free of imperfections.

Available in liquid or gel form, the coating is a complex formulation (lanolin, petroleum oil).

The coating can't be used where a soft film is objectionable. This rules out stairways, floors, or any equipment subject to abrasion or erosion. Also, present formulations are soluble in petroleum solvents.

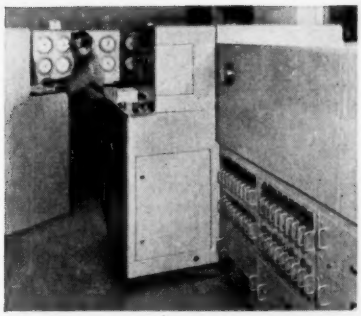
A number of chemical companies—working with 1 to 5 bbl. of material—are testing Eureka's coating. A few tests include internal coatings in tanks. But the majority are external applications. It is too early to report any definite conclusions. But preliminary tests indicate the gel film is promising on pipe lines, containers or equipment subject to corrosive fumes. At about 29¢/lb. the material is expensive as a protective coating, but with a long service life, overall costs should be low.

Big, Long Polyethylene Pipe Links Two Plants

Here's a good example of polyethylene stepping into the big league: 1.19 miles of 6-in. dia. carbon-filled polyethylene pipe now links Mallory-Sharon Metals Corp.'s zirconium and titanium plant to U. S. I.'s sodium plant at Ashtabula, Ohio.

Requiring little maintenance, the pipe (U. S. I. produced polyethylene) carries a saturated brine solution at 80-90 F. and around 65 psig.

Polyethylene rings were flanged to both ends of 30-ft. pipe sections by hot gas welding (polyethylene rod and N_2). Split steel back-up rings, coated with polyethylene, strengthen each flange. Carbon steel bolts and cast iron valves are also used.



A spectrometer checks every heat. Changes can be made before metal is poured.

When you have a galling problem in metal-to-metal contact ☐

or galling and corrosion-resistant problems ☐

investigate castings made with

Waukesha

metal 23* or 88*

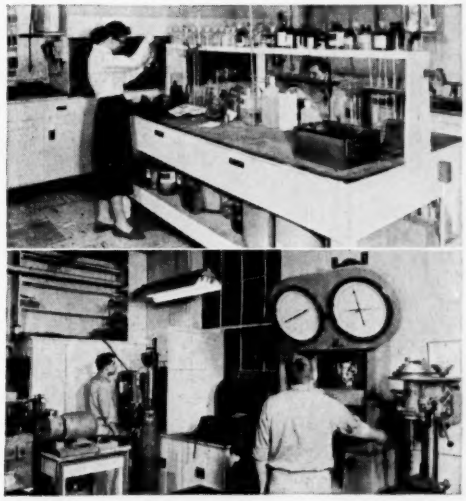
Perhaps you've tried heat treating 400 Series stainless steel alloys to solve your galling difficulties . . . and found the metal has become so hard it can't be machined. Or perhaps serious distortion occurs.

Perhaps you've tried various other alloys and found they don't measure up for *every* performance requirement . . . Either non-galling characteristics or high corrosion resistance are difficult problems separately. Combined they are an impressive engineering headache.

But WAUKESHA Metal 23 or 88 provides non-galling performance even under high speed metal-to-metal contact AND both are highly corrosive-resistant. Both are remarkably free-machining, without hard or soft spots. Both are homogeneous in texture.

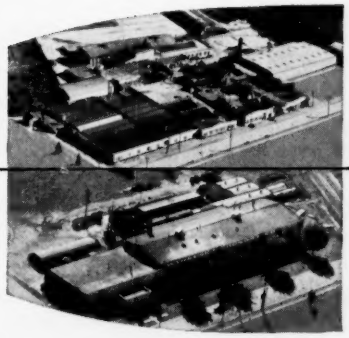
WAUKESHA 23 and 88 have solved many of the most difficult casting problems in a great range of industries. We're glad to supply you with a list.

Or better still, write us. Describe your problems and the conditions which must be met. More than likely we'll have the answer for you.



Two views of the Waukesha Metallurgical Laboratory — one of the most complete in the country.

* *So unusual and different are WAUKESHA Metals 23 and 88 that patents have been granted on both formulations.*



Waukesha Plant

Watertown (Wis.) Plant

Waukesha

FOUNDRY COMPANY

DEPT. U-1, WAUKESHA, WISCONSIN

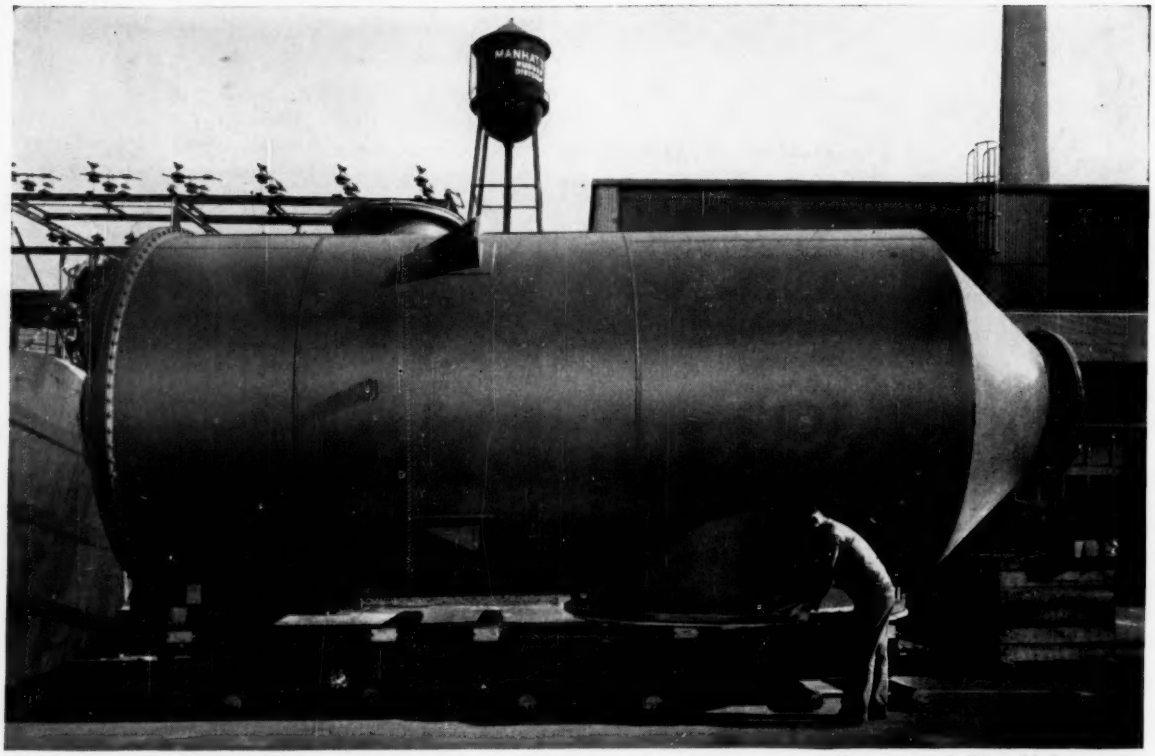


Photo courtesy, Croll-Reynolds Company, Inc.

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Protect One of the World's Largest Rubber Lined Barometric Condensers

This unit measures a big 22 feet long by 10 feet in diameter. And, because every square inch is rubber lined by Manhattan, every square inch is protected against corrosion . . . *permanently!*

Costly process equipment and solutions deserve the degree of protection against corrosion, contamination, and abrasion possible only with specially compounded, acid-proof Manhattan Rubber Linings. These linings are made from thick, multiple calendered sheets of natural or synthetic rubber for maximum durability under your specific conditions. Manhattan engineers have developed a method of bonding the rubber to the metal so securely that actual tests have proved they can't be separated! Manhattan linings expand and contract with the metal under temperature changes . . . they won't harden or crack. Resistance to most acids and alkalis is as positive as advanced technology can provide.

Equipment size or shape is no problem when you rely on Manhattan. If the unit can be shipped, it can be lined at Manhattan. Equipment too large to be shipped can be field lined and vulcanized by skilled Manhattan crews. The most modern and complete lining facilities available today, plus experience dating back to the first tank lined in this country, is ready to handle your job. To make certain your lining is flawless *and* permanent . . . every Manhattan Lined Tank is tested under high voltage.

For *permanent* protection for your equipment and processes, discuss your tank lining requirements with the R/M representative at the Manhattan Rubber Lining plant nearest you . . . Write for new Tank Lining Catalog #7115. RM704

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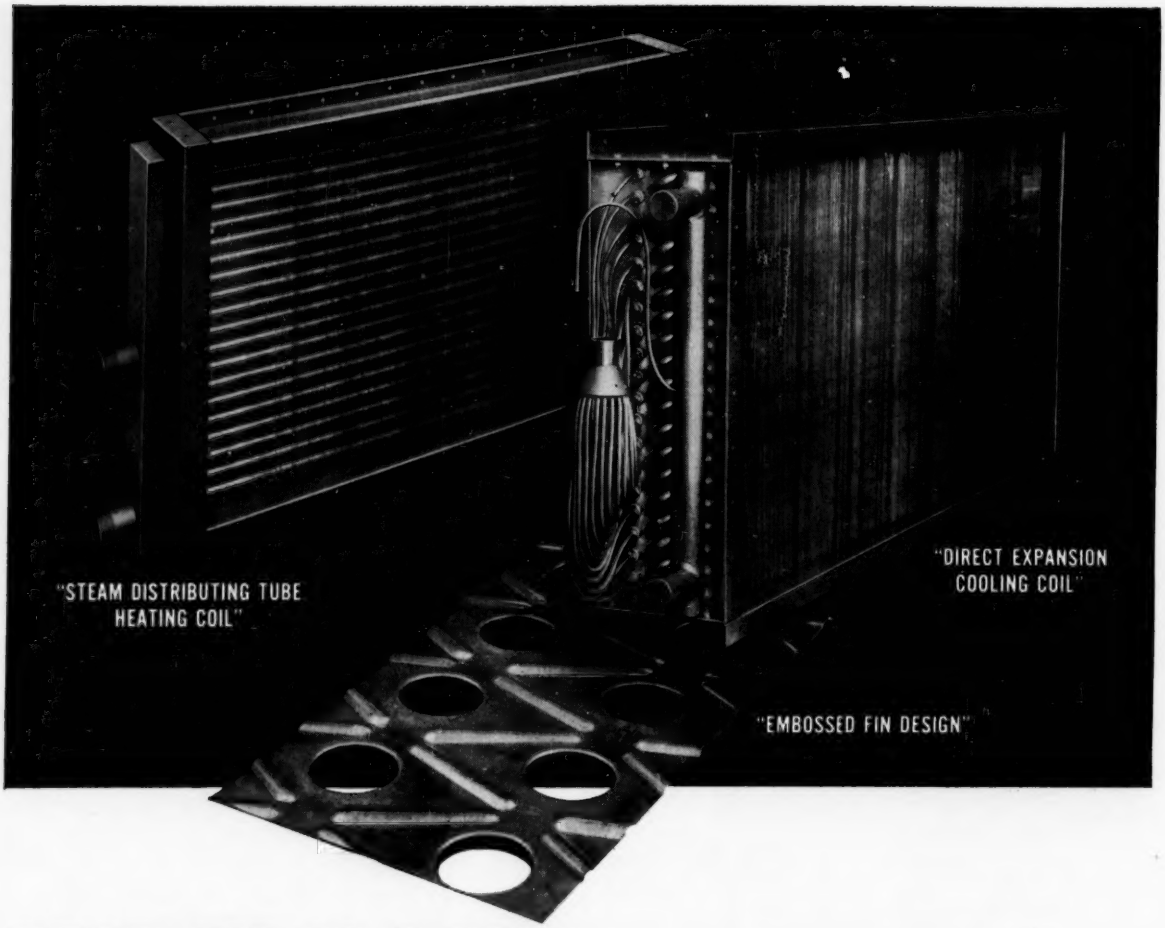
Chemical Engineering

People

JAN. 27, 1958

Department Index



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Dead-air film on smooth fin surface prevents maximum heat transfer!

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YOU CAN BE SURE...IF IT'S Westinghouse

HOW TO . . .

Run an Effective Meeting

As you climb up the management ladder, you'll be expected to become more adept at leadership of meetings. Here are the 12 "do's" and 6 "don'ts."

Walter L. Knighten, Gulf Oil Corp., Port Arthur, Texas*

Want to be a better supervisor in the eyes of your men, in the eyes of higher management and, incidentally, in your own eyes? A good way to take a long step in that direction is to become known as a person who can lead a good, productive meeting.

Ability to run good meetings is not a "gift of the gods" which has been passed out to a lucky few and withheld from the rest of us. It's an ability that can be acquired by your own efforts and improved with practice.

Two Main Ingredients

The main ingredients that go to make up a successful meeting are: planning and leadership. Leading is what supervisors get paid to do, and part of that job involves leading meetings.

For one thing, meetings are strong, effective tools to use in keeping the channels of communication open. Supervisors call meetings to inform their people about changes in company policy, job methods, work schedules, wages and benefits, etc.

In these days, when the use of teams is taking over some of the decision-making function in management, supervisors are using meetings to help solve problems in: accident prevention, job simplification, human relations, research, engineering, production and many other areas.

Here's What Not to Do

However, the fact of the matter is that many meetings are not nearly as effective as they could be. Here are some of the more serious things that can go wrong:

- The leader does not have a clear purpose.
- Meetings are held simply to please those in higher authority.
- Meetings are not preplanned. The group doesn't understand what the meeting is all about.
- Ideas are not presented in logical order.
- The leader passes over problems and questions from the group.
- The meeting breaks down into arguments and side discussions.

What Does It Take?

How does one become a good leader of meetings? Try following these twelve simple pointers in your own personal on-the-job training program. See if they don't help to make your meetings more productive—even more enjoyable.

Here they are:

1. Have a planned outline.

Start with a definite purpose. Ask yourself: "Do I need to have a meeting? What do I want to accomplish?" And, you will want to catch and hold the group's interest from the very start. Ask yourself: "What is the best way to introduce my subject. Can I do it with a demonstration? A skit? A statement of the problem? Asking a question? Making a controversial statement?"

ABILITY TO RUN MEETINGS is not a "gift from the gods." It can be acquired with work.

MAIN INGREDIENTS that go into a successful meeting are: planning and leadership.

* Meet your author on page 164.

SET REACHABLE GOALS. Don't set your sights too high.

MAKE FULL USE OF VARIETY to liven up your meetings.

START AND STOP ON TIME. There's no time to dawdle.

Remember the purpose of the meeting. Ask yourself: "How can I develop my subject, step by step, towards accomplishing my purpose? What main points should I make? What questions can I ask the group to stimulate their participation? What questions should I ask in case the discussion lags?"

When you summarize: Remind the group of your original purpose. Ask yourself: "Where should I sum up to make sure the group is with me and to crystallize their thinking? After which points? What is the best way to sum up the meeting and close it out?"

Using the above guide, you should be able to rough out a meeting in 15 or 20 minutes. Depending upon your purpose, you may need nothing more elaborate than this. Or, you may want to work it out in detail.

2. Make all the necessary arrangements.

Don't assume or leave anything to chance. Decide who will attend. Decide on the best available place to hold the meeting. Set the date and time. Tell your people about any notes, reports, etc., that you expect them to bring. Make sure that paper, pencils, chalk and any other necessary materials are available. Also, make sure that films, projector or other aids you may want to use will be ready when you need them.

3. Set reachable goals.

Don't attempt more than you can handle. Ask yourself: "How much time can I afford for this meeting?" When you know how much time you have available, tailor your meeting to fit.

4. Make full use of variety.

Keep this in mind while planning each of the three main parts of your meeting (introduction, presentation, summary): Use every means you can think of to catch and hold interest. Ask yourself: "What techniques and devices can I use to liven up the meeting and hold interest?"

With a little planning, all you need for many of your meetings is a place to hold it, a purpose, an outline and something to write notes on. Often, these may be only of the most informal sort: a spot out of everyone's way, a plan roughed out on the back of an envelope and a soft rock or stick to scratch a drawing or two on a piece of boiler plate or on the ground.

On the other hand, for your regularly scheduled meetings—such as your weekly or monthly safety meetings—there are dozens of ways to work in a little variety. Here are some of the devices you can use to introduce your subject, nail down some important points, stimulate group thinking, sum up, or give a new twist to the whole meeting:

Movies, film strips, slides, illustrations using opaque projector, demonstrations, skits, play acting, chalk-board illustrations, flip charts, graphs, case materials.

5. Start and stop on time.

There isn't time to dawdle. You have a definite purpose to accomplish in a specified time. Running a businesslike meeting is a good indication of planning and leadership. It sets a good example for the group and helps gain their respect.

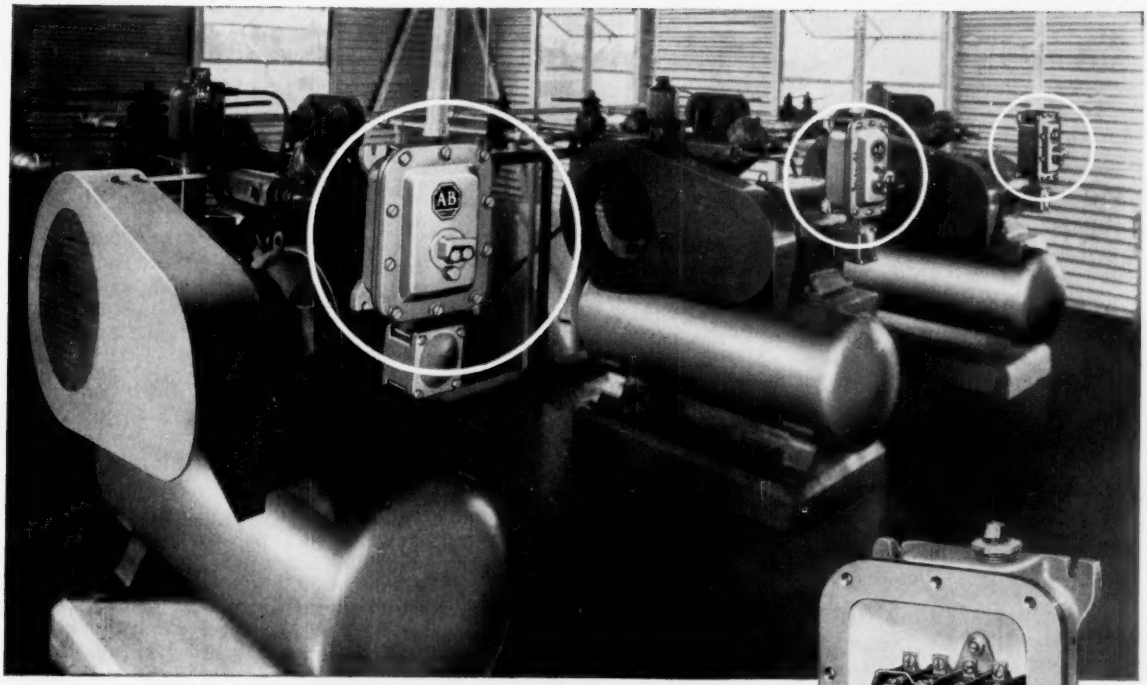
6. Go after group participation.

Give people a chance to talk. In fact, plan for group participation. Let them get their misunderstandings and problems out in the open. People understand better when they discuss and talk over a subject. And they certainly won't get bored. Then too, encouraging participation helps you check on attitudes—gives you a chance to nip some problems before they become serious.

Make an effort to draw out the timid and reserved. It's usually worth it. Ask for their opinions; make it easy for them to answer.

7. Be patient.

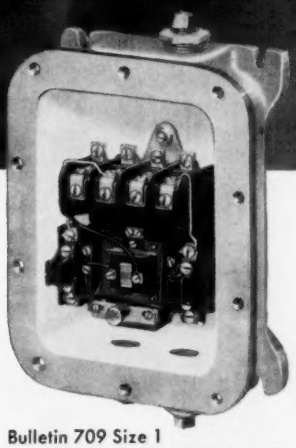
Remember that you want the group to move with you towards accomplishing your purpose. Don't press them too hard when they want to stop and chew over a point. It will be obvious to you when they get off the subject. Then you can push them back on the track, being as nice about it as possible.



Allen-Bradley explosion-proof starters in an LP gas terminal.

Don't waste time removing covers!

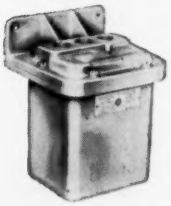
Allen-Bradley starters are good for millions of operations . . . without maintenance



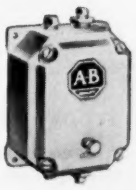
Bulletin 709 Size 1
Solenoid Starter in NEMA Type 7
explosion-proof enclosure.

Type 1 General Purpose Enclosure

Type 4 Watertight Enclosure



Type 8, Oil-Immersed for Hazardous Corrosive Gas



Type 9, for Hazardous Dust

A-B QUALITY

Because so much time is lost in removing and replacing the bolted covers of explosion-proof starters, it's important that the starters operate over long periods without service attention. That's why you ought to buy Allen-Bradley starters. Having only *one* moving part, these starters are good for millions of trouble free operations. The double break, silver alloy contacts never need servicing . . . they are *always* in perfect operating condition. For the starter you can install—and forget—specify Allen-Bradley. Send for the A-B Handy Catalog . . . a guide to *quality* motor control.

Allen-Bradley Co., 1337 S. First St., Milwaukee 4, Wis.
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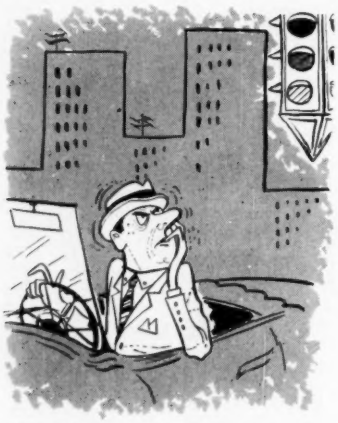
ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

KEEP ON THE SUBJECT. Don't forget your outline.



BE PATIENT. You want the group to move along with you.

TELL YOUR BOSS what you accomplished at the meeting.

8. Summarize frequently.

Use the summary during the presentation phase of your meeting—as well as to review and close out the meeting. Summarizing after several main points have been made serves as a progress report to the group as it moves toward accomplishing its purpose. Using summaries in this fashion helps to crystallize thinking on the points that have been made.

9. Keep on the subject.

Don't forget your outline and what you want to accomplish. You haven't much time for side issues. Still, it's a good idea to make a note of questions and problems that the group thinks are urgent. Be diplomatic, but get back on the subject. You can come back to them at a later time.

If the group is especially bad about straying from the subject, you may need to work at developing a sense of group responsibility: Provoke casual after-meeting discussions on "how we can improve our meetings." Be subtle about it and you can kill two birds with one stone. You can let the group members know that they too have a responsibility for making the meeting a success; and you can get some ideas on how to improve yourself.

Ask the group: "What about the meeting place? Ventilation O.K.? What about the seating arrangement? How loud was my voice? Loud enough? Did we stay on the subject? Did I summarize often enough? What about the chart or the board work? Did everyone have a chance to talk? Did anyone monopolize the discussion? Did we accomplish our purpose?"

10. Be sure that everyone understands what was acomplished at the meeting.

In your final summary review your most important points and show how the meeting accomplished its objectives. If action is required, make sure that each person knows what is expected of him.

11. Tell your boss what you accomplished.

Your boss needs all the information he can get. He has to know your plans and objectives if he is to give you the backing and support you will need to carry them out.

Remember that it's part of your job to keep communications open up the chain of command as well as down through it.

12. Follow through on results.

Look out for those who might not have understood what was agreed upon. Some people have to be prodded. See to it that procedures agreed upon are followed, and check to see that meeting results are being applied.

Finally, pass ideas and suggestions beyond your level of authority up the chain of command.

Ask yourself: "What can I do to make my next meeting better than this one?"

Try Planning and Leadership

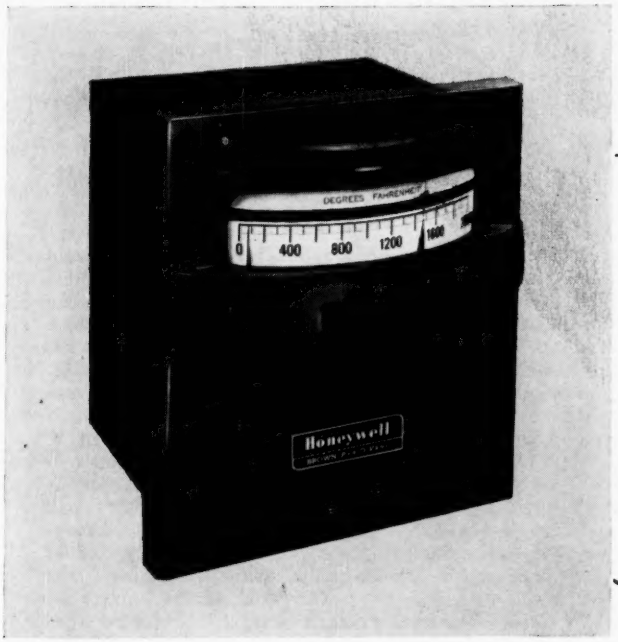
There you have a simple 12-step guide to better meetings. But remember that whatever your meeting, it requires planning and leadership to be successful. Every meeting should meet and satisfy a definite need.

Practicing our own advice, we summarize:

1. Have a planned outline; 2. Make all necessary arrangements; 3. Set reachable goals; 4. Make full use of variety; 5. Start and stop on time; 6. Go after group participation; 7. Be patient; 8. Summarize frequently; 9. Keep on the subject; 10. Be sure that everyone understands what was accomplished; 11. Tell your boss what you accomplished; and 12. Follow through on results.

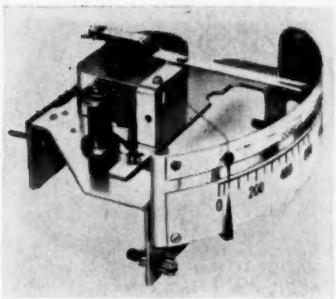
Next Issue: Roundup on a Trilogy of Controversy

Letters. We get lots and lots of letters. About: How a federal judge in Albuquerque has reversed Internal Revenue's rulings on moving expenses. About: What salary would you expect to receive? About: The engineer shortage, more or less. In our next issue, we'll report on these three stories of disputatious difference.



***Pyr-O-Vane* Millivoltmeter Controller**

Available in 150 standard ranges, and a variety of control actions. Both vertical and horizontal models can be flush or surface mounted.

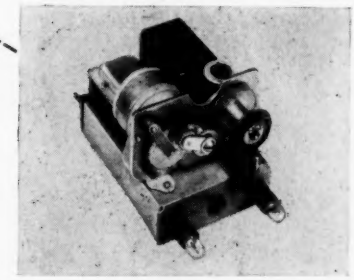


Plug-in galvanometer unit ▲

High-strength *Alnico* magnet makes possible larger gap between magnet and core, reducing clogging due to dirt and dust. Triple ambient temperature compensation provided.

Plug-in pulse *Pyr-O-Vane* control unit

Control units available with choice of 10 different control forms. Proportional band adjustable between 1 and 3%; cycle timing change gears available for 3, 7.5, 12, 18, 30 or 72 seconds. ▼



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PEOPLE . . .

TECHNICAL BOOKSHELF

J. B. BACON

For All in Polymers

FREE RADICALS IN SOLUTION. By Cheves Walling. John Wiley & Sons, Inc., New York. 631 pages. $14.50.

Reviewed by F. C. Nachod.

At a very timely moment, Dr. Walling has prepared an up-to-date book on free radicals. This book will be of great interest to anyone wishing to appraise the status of our knowledge in free radical chemistry. It most certainly will be welcome to all interested in fields of polymers, elastomers, and plastics.

In organizing his subject matter he has used the viewpoints of reasonance energy of radicals, and of steric and polar effects. The first two chapters deal with the structure and physical properties of free radicals, with their chemical reactions and their associated bond dissociation energies. The following three chapters cover vinyl polymerization and provide the reader with detailed knowledge of the kinetics of radical controlled chain processes.

Chapters six through nine treat polymerization in other systems, additions to double bonds, substitution, and oxidation processes. In the last two chapters various non-chain processes, photochemistry and redox systems are dealt with.

Progress Report

CHEMICAL ENGINEERING IN THE COAL INDUSTRY. By Forbes W. Sharpley. Pergamon Press, London. 141 pages. $8.50.

Here is a progress report from western Europe on the recently accelerated application of chemical engineering principles to the treatment of coals. It consists of seven papers and the discussions they stimulated at a conference of key technical men in western Europe's coal industry sponsored by Britain's National Coal Board in June 1956.

Papers covered controlled oxidation of coal in France, British work on fluidized oxidation, investigations into the carbonization of briquettes in Germany, hot briquetting in Great Britain, British study of tars obtained in fluidized carbonization, industrial treatment of tar obtained by low-temperature carbonization in France and, arousing the widest interest and discussion, a French study of semicarbonization in a fluidized bed.

Estimates, official and unofficial, are that the continent's economy depends fundamentally on the prosperity and technical progress of the coal industry during the next 20 to 30 years. Throughout Europe today the average efficiency at which coal is used is still less than 25%. Utilization of this reservoir to plug the gap in energy resources was the common thread running through process research and development work described at the conference.

However, individual papers and discussions reflected characteristic national needs: The French contributions centered on the problem of producing good coke from coals which do not lend themselves to coking. The same problem, shortage of good coking coals, was seen even more acutely in the contribution from Poland. A contribution from Germany laid special emphasis on the making of briquettes for the special purpose of smelting. A British preoccupation was with the making of efficient fuels for the open fire.

Degree of application of new process developments is very unequal in different countries. In Great Britain, they are most often still at the ton/day stage; in France, they've reached a ton an hour; German development is on a still larger scale. But apparently the European work does not approach the large scale of pilot development in America nor does it share American emphasis on turning coal into liquid products.

General conclusions drawn from the papers revealed several unsolved problems. One is the difficulty of removing the entrained solids from a gas stream after any process of fluidization; the prospect of introducing the continuous processes of modern chemical engineering into the coal industry may depend critically on ability to keep the powder of the fluid bed in the plant.

Another problem revealed in the book is that of creating special uses for the special byproducts which new processes will yield. Further, the fact is recognized that what is a byproduct problem today will become the primary goal of the long-range future. Despite the urgent need for coal as a stop-gap energy source, its days in that role have most certainly been numbered to a maximum of 30 years by atomic energy. Ultimately, the industry must either stand or fall on the basis of coal's chemical content and methods for recovering and using it. By pointing up areas of new scientific understanding of the fundamental transformations of coal, and areas where understanding is conspicuously lacking, this book, and the development work it represents, aims to serve both today's and tomorrow's goals.—FA

An Up-to-Date Reference

SOUTHWEST RESOURCES HANDBOOK. Compiled by Southwest Research Institute, San Antonio, Tex. Subscription price: $250 first year, $100 a year thereafter.

This is a single, comprehensive source book in two volumes of basic information on the resources of the southwestern United States and the Republic of Mexico. There is material about the area as a market, as a source of raw materials and as a processing location. There are separate sections on energy resources and mineral fuels, mineral resources and their role in the economy, soils and native vegetation, forestry, water, fi-

nance (federal, state and local), transportation and communication, human resources for economic development, agriculture (data, trends and research progress), construction, research and other business services and recreation and tourism.

The handbook forms the nucleus of a continuous service in compiling factual information on the resources of the area. Yearly research supplements assure an up-to-date reference at all times. As its scope continues to expand the value of the handbook should increase. The binders are loose-leaf style, designed for easy expansion to accommodate the additional material.—JAL

BRIEFLY NOTED

ABSORPTION COOLING PROCESS. 44 *pp. By R. T. Ellington, G. Kunst, R. E. Peck and J. F. Reed. Institute of Gas Technology, Bulletin* 14. *Institute of Gas Technology, Technology Center, Chicago* 16, *Ill.* $5. Searches and reviews literature on theory and application of closed absorption cycle and systems currently used.

BASIC RESEARCH—A NATIONAL RESOURCE. 64 *pp. Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.* 45¢. Describes and reviews position of basic scientific research in the U. S.; suggests ways to encourage basic research.

MORE NEW BOOKS

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY, 1ST SUPPLEMENT VOLUME. By Raymond E. Kirk and Donald F. Othmer; Assistant Editor: Anthony Standen. Interscience. $25.

PROCESS INSTRUMENTS AND CONTROLS HANDBOOK. Edited by Douglas M. Considine. McGraw-Hill. $19.50.

HEAT TRANSFER, Vol. 2, By Max Jacob. Wiley. $15.

ECONOMICS OF ATOMIC ENERGY. By Mary Golding. Philosophical Library. $6.

THE PROPERTIES AND TESTING OF PLASTICS MATERIALS. By A. E. Lever and J. Rhys. Chemical Publishing Co. $4.75.

X-RAY CRYSTAL STRUCTURE. By Dan McLachlan, Jr., McGraw-Hill. $15.

PEOPLE...

MEET YOUR AUTHORS

M. A. GIBBONS

Walter L. Knighten

HOW TO RUN A MORE EFFECTIVE MEETING. PAGE 157

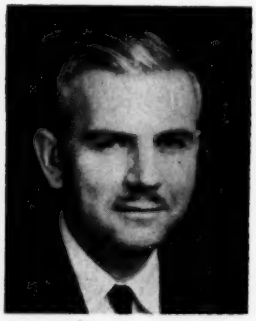
With a background in English and petroleum geology, Walter Knighten is a "professional engineer" in the employee relations department at Gulf Oil's Port Arthur refinery in Texas.

Knighten tells us that ever since his discharge from the Air Force in April 1946, he wanted to become a writer. That's why he enrolled in English at the University of Texas. But, by the time graduation rolled around, he had acquired a wife and a healthy respect for the necessity of making a living. So, a follow-up in the field of geology seemed more practical.

First job after leaving school was with the Texas Board of Water Engineers. Though the GI Bill had produced a surplus of geologists in this area, he was hired, actually, because of his degree in English. Then, a year later, his degree got him another job as a junior management assistant with the Air Force. This gave him a sound background in the field of employee training.

Two years later, Gulf hired him—again on the basis of his degree and experience. So, it seemed, the B. A. in English wasn't so impractical as he'd originally thought.

But Knighten's desire to do actual writing has never lessened. And, one way or another, he has managed to keep in close touch with the field. He teaches "Written Communication" at Lamar State College of Technology at Beaumont, Tex. And, his regular job calls for considerable writing in the way of training materials. In fact, it was the development of a training manual for use in improving safety meetings that led to the current article.



L. Wallace Coffer

ATOMIC-AGE METAL EXTRACTION. PAGE 107

As assistant division chief of the extractive metallurgy division, Battelle Memorial Institute, Wallace Coffer has been associated, to some extent, with many of the processes he discusses in his current article.

Coffer joined Battelle in 1952, after completing requirements for his Ph. D. Before that time, he worked as a research associate at the University of Pittsburgh, studying low temperature heat content and entropy of Cd-Mg alloys.

Earlier in his career, Coffer worked as a research chemist in the Detroit research laboratory of the Climax Molybdenum Co. of Michigan. There he did research on printing ink pigments containing molybdenum. In 1940, he became plant control chemist for the firm's Langeloth, Pa., conversion plant. Work comprised research and process improvement in extra-active metallurgy and use of molybdenum, its compounds and alloys. Processes involved included roasting, leaching, chemicals production, chlorine metallurgy and hydrogen reduction.

This isn't the first time that Author Coffer's work has appeared in print. He has also published in the American Ink Maker and in the Journal of the American Chemical Society on the subject of metals.

Coffer earned his bachelor's and master's degrees from the University of Arizona. Later, he attended Michigan State College and received his Ph. D. in physical chemistry from the University of Pittsburgh.

Walter Coopey

HOW TO SOLVE SOFT PACKING PROBLEMS. PAGE 131

Though problems of high-pressure technique do not comprise Walter Coopey's only field of endeavor, over the years he had become a recognized authority in that area. And, since packing is an important factor in high-pressure operations, he has always taken an interest in that field, too.

What with his interests and background of experience, he developed confidence that he could devise a packing for any service at any commercial pressure. Because of this confidence, some five years ago he accepted an assignment on a guarantee basis to provide a packing for a centrifugal pump. Though the service was rather severe, the pressure was relatively low and he expected the job to be a simple matter.

To his surprise, it was a tough job. He found that he still had something to learn about pack-

ings. For a while, it looked as if he might lose not only the fee but some of his confidence as well. However, he did come up with the solution—which is described in this article. Although it turned out to be simple, he did not discover it until he'd tried most of the well-publicized cures for packing troubles.

Engineering consultant Walter Coopey got into the chemical industry almost by accident. A couple of years after his graduation from Penn State with a degree in mechanical engineering, he took a job with the Roessler & Hasslacher Chemical Co.—now Du Pont's electrochemicals department. There he worked as a development engineer on various chemicals, including ammonia. In 1930, when the firm was taken over by Du Pont, he transferred to Du Pont's ammonia works at Belle, W. Va., as engineering manager. He remained there until his retirement in 1950—a total of 33 years service.

During recent years at Belle, Coopey served as a company consultant and has continued in consultation ever since.

Thomas G. Nock

BUILD OR REPAIR WITH EPOXY-GLASS LAMINATES. PAGE 148

Early last year, Thomas Nock was appointed assistant to the manager of Shell Chemical's newly created sales development department.

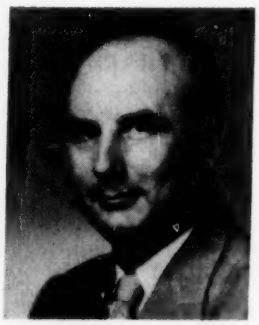
For the previous five years, he had worked on plastics and resins at the firm's head office in New York City. Originally, Nock joined the company's research affiliate—Shell Development Company—in June 1938. He was hired as a laboratory as-

AUTHORS . . .

sistant at the firm's Emeryville, Calif., research center.

During the course of research assignments on projects including petroleum cracking, catalytic refining and process development, he was promoted to the posts of junior chemist and chemist.

Nock is a chemical engineer with a B. S. degree from Oregon State College. He is a member of the Society of the Plastics Industry, Society of Plastics Engineers, the National Association of Corrosion Engineers and the Highway Research Board.



Maxey Brooke

CE FLOW FILE. PAGE 140

This issue marks the close of Maxey Brooke's very useful series, the CE Flow File. Looking back over the course of the last 13 months—which it took to run the series—Maxey tells us that he thoroughly enjoyed writing the series and made a number of new friends as a result of it.

Maxey's main occupation is with Phillips Petroleum Co., in Texas. Though classified as a supervisory chemist, his work is mainly administrative.

Brooke in 1940 joined a sulfur company on the Gulf Coast as a chemist.

That first assignment in the chemical field was followed by a term with the U. S. Army Chemical Corps: a two-year stint part of which he spent as an observer at the Bikini atom bomb tests. It was at this time—during spare moments at Bikini—that he initiated the collection of fluid flow formulas which resulted in this very successful series.

F. C. Jelen

REMEMBER ALL THREE IN COST ANALYSIS. PAGE 123

The first article of Jelen's current series on cost analysis talked about the importance of considering "a return on investment." Jelen's next contributions covered "the effect on inflation." After that he came up with his treatment of income tax considerations.

This current article rounds off the last three—to give you a thorough treatment on handling all three subjects for the best possible cost analysis.

And, next on the Jelen agenda is a comparison of all the different methods of analyzing project costs. Jelen has facetiously labeled this coming ambitious work his "Swan Song" in the field.

On a full-time basis, Jelen is a chemist for the Solvay Process Division.

John R. Hefler

CHEMICAL PROPORTIONING CALCULATIONS. PAGE 129

John R. Hefler started his career in industry with Proportioneers, a division of BIF Industries, in 1943. During his association with the firm he has worked as research engineer, de-

AUTHORS . . .

velopment engineer and development supervisor.

In the course of his work, he realized that many of the calculations useful in designing chemical proportioning systems would be valuable in starting up projects and in their actual operation as well.

Hefler studied chemistry at Cornell University. Later he did graduate work in chemical engineering at the University of Rhode Island.

Today, Hefler lives in Jamestown, R. I., where he is quite active in civic affairs. He is a member of the town planning board and secretary of the Citizens Progressive League.

Richard A. Coderre

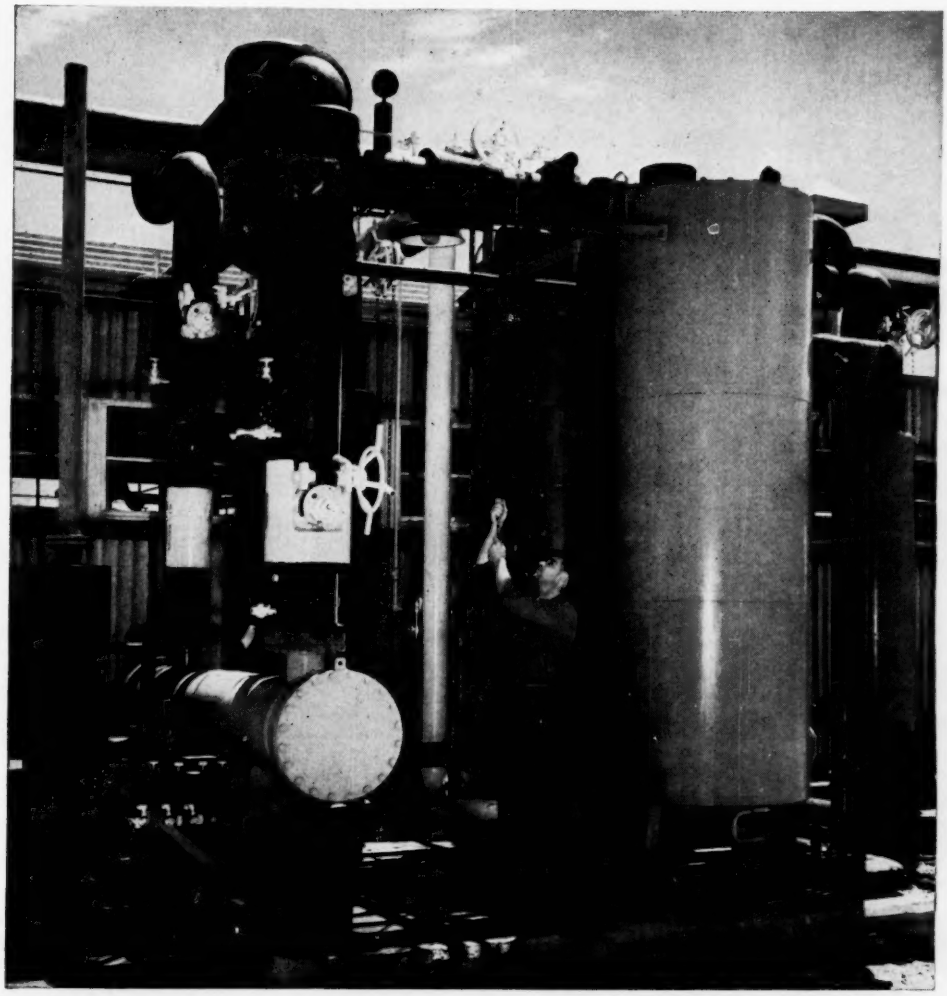
BUILD OR REPAIR WITH EPOXY-GLASS LAMINATES, PAGE 148

Shell Chemical's Richard Coderre is a technologist in chemical marketing in the firm's New York chemical sales div.

Coderre originally joined the firm, in 1952, at the technical service lab in Union, N. J. There, he worked on customer problems and product development in the use of epoxy resins.

Dick was born in Chicago and earned his chemical engineering degree from the University of Illinois, in 1949. He went on to earn a doctorate in organic chemistry from Massachusetts Institute of Technology in 1952.

The current article isn't the first of Dick's contributions to the technical publishing world. In addition to a number of other articles, he has to his credit the item on epoxy resins in the Encyclopedia of Chemical Technology.



Type BWC Lectrodryer on-stream at Hooker Electrochemical Company, Montague, Mich.*

DRY hydrogen required for production and pipeline transmission

Hydrogen, a by-product from electrolysis of sodium chloride brine, is used for producing anhydrous HCl gas. It must be DRY for this purpose, so Hooker Electrochemical passes it through this Lectrodryer*.

This DRYing also makes it possible to transmit the gas through uninsulated pipes during cold weather. There's no moisture in the hydrogen to cause freezeups.

On-stream continuously, the Lectrodryer handles this DRYing without interruption. Its valves are reversed every eight hours, putting one tower on DRYing while the other is being regenerated. No other attention is required.

Because Moisture Isn't Pink tells how others are using Lectrodryers. For a copy, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 303 32nd St., Pittsburgh 30, Pa.

Lectrodryer

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AISI TYPES			SUPER CORROSION-RESISTANT TYPES
302	310	321	Carpenter Stainless No. 20Cb
304	316	347	Carpenter 7Mo
304L	316Cb	348	Carpenter Alloy B
309	316L	430	Carpenter Alloy C
309S	317	442	Titanium 55 and 70
309SCb	317L	443	

Other specialty grades in various stages of development are available: Zirconium, Zircalloy 1., 19-9 DL, Invar, HiMu80, N-155, Haynes No. 25 (L-605), Hastelloy F and Hastelloy X, Armco 17-7PH, Titanium alloys, A-286 and others.

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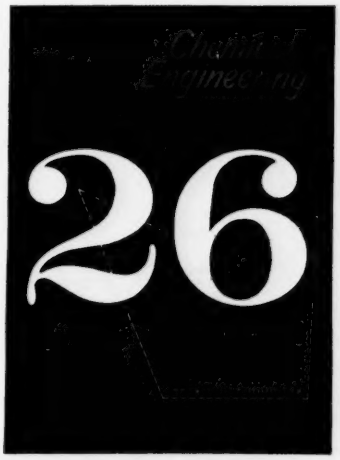
LETTERS: PRO & CON

C. H. CHILTON

That big "26" you see here will mean a lot to you in 1958. How?



- It means 26 streamlined issues that'll be faster to read, easier to take home in your briefcase.
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- It means CE can now give you more—yet save you time—through faster, better, broader coverage than ever before.
- **Be sure to let us know what you think of the job we're doing;** this will help us serve you—as well as all chemical engineers—even better in the future. Simply address your letter or postcard to Editor, *Chemical Engineering*, 330 W. 42nd St., New York 36, N. Y.

Pro: Perforated Pages

Sir:

I have subscribed to *Chemical Engineering* for a long while. I usually go through every issue, particularly through the advertisements, and tear out the pages that contain anything of interest to me. This is a very convenient way of following up the different items that attract my attention.

Many times it is difficult to tear these pages out. It would be much easier if the pages were perforated along the bound edge. The page removed would have a very clean edge and would be much easier to file.

E. H. ELLISON, JR.
Elkland Leather Co.
Boston, Mass.

▶ *We've had the question of perforated pages under consideration for several years. And we're planning another intensive study soon. If everyone agreed with Mr. Ellison, our decision would be a simple one. However, there are many who vote against perforated pages, and for very good reasons.*

We'd like to hear from more of our readers about this question. Just drop a note to Editor, Chemical Engineering, 330 W. 42nd St., New York 36, N. Y.—ED.

We Pulverized This One

INTER-OFFICE MEMORANDUM
To: John Callaham
From: Bob Frederick

In the Inventory Issue, in the directory of exhibitors at the Chemical Show, we incorrectly ran the following item under the name of Pulva Corp.:

"Presenting a new conception in dust collection—the first major advance in that field in a decade. Showing how pulverizers and feeders fit into the processing picture."

This item was misplaced; it should have appeared under the next listing, that of Pulverizing Machinery Div., Metals Disintegrating Co.

M.W.'s of Hydrocarbons

Sir:

I have read with interest the article, "Generalized Heat Capacities," in your October issue (pp. 283-288). It should certainly be of help to the practicing engineer in providing a ready source of information.

However, there is an error which I noticed in Fig. 4. The right-hand scale shows molecular weights on one side and hydrocarbon names on the other. The error lies in the mismatching of names with molecular weights. For example, ethylene (m.w. = 28) is shown having a m.w. of 24. Similar discrepancies appear with respect to propylene, isobutylene, isobutane, butane-2, isopentane and benzene.

F. J. SPENCER
Monsanto Chemical Co.
Texas City, Tex.

▶ *These apparent discrepancies are adequately explained in the text of the article (p. 288, Col. 1). Since the nomograph (and the m.w. scale) were developed for the normal paraffin hydrocarbons, the positions of olefins and aromatics are empirical and do not correspond to their molecular weights.*—ED.

Pro: Thermal Conductivity

Sir:

Recently I heard of your excellent articles on thermal conductivity for liquids and gases which were published this year. I would appreciate very much receiving reprints of these articles if available.

H. BRAUER
Max Planck Institut fur
Stromungsforschung
Goettingen, Germany

▶ *First three installments of the Gambill series, covering the estimation of thermal conductivity of liquids and gases, are now available as Reprint No. 94, 50¢.*—ED.

PEOPLE . . . NAMES IN

John A. Field

John A. Field, a vice president with Union Carbide Chemicals Co. since December, 1954, will fill the company's newly created post of vice president—marketing. In this position he'll be in charge of all of Carbide's chemical marketing functions, now being consolidated in an integrated company marketing organization.

Field has had over 22 years experience with Carbide in production, research, new product and sales development. Until his recent promotion, he was responsible for sales development and related activities, including the company's fellowships at Mellon Institute.

H. E. Benson, J. H. Field, R. M. Jimeson, W. P. Haynes, Daniel Bienstock, J. S. Tosh, L. W. Brunn and **G. E. Johnson** are eight Bureau of Mines chemical engineers in the Pittsburgh, Pa., area who have been presented a group award totaling $1,100 for developing the hot carbonate scrubbing process—a method by which the cost of removing CO_2 from gas is cut in half.

Norman P. Phillips has been promoted to the position of manager of sales development for General Tire & Rubber Co.'s chemical division.

G. C. Zwick has been appointed special field representative for Goodyear Tire & Rubber Co.'s chemical division. With headquarters in Chicago,

THE NEWS

M. A. GIBBONS

Zwick will provide sales and technical service for high polymer resins, rubbers and latices marketed by the chemical division.

A. F. Sward is now manager of market research for Bakelite Co. Division of Union Carbide Corp. Three of the company's new product general managers are **J. L. Brannon** (phenolics), **L. E. Humphrey** (polystyrene) and **W. R. Wheeler** (vinyls).

Norman E. Hathaway

Election of Norman E. Hathaway as director and vice president—marketing for Oronite Chemical Co. has been announced by the company's president.

In his new job, Hathaway will direct all marketing of Oronite chemical products through company sales offices both here and abroad.

Hathaway joined Oronite in 1954 and, until his new appointment, served as general sales manager. Before joining the company he was director, chemical and rubber division, business and defense services administration, Dept. of Commerce, Washington, D. C.

Noah S. Davis, head of Food Machinery & Chemical Corp.'s special projects branch, has been promoted to the position of director of this branch, which has now been estab-

lished as a central chemical function of the company.

Lee A. Crenshaw has joined the staff of Texas City Refining as a technical services engineer.

David S. Rosenberg has been appointed manager of process improvement and development for Hooker Electrochemical Co., Niagara Falls, N. Y. Other recent appointments within the company include **James E. Dillman,** technical supervisor, process study; **Elliott P. Doane,** supervisor, pilot plant; **Benjamin W. Hancock,** technical foreman of Area 4, where Oldbury products are manufactured.

James R. Caldwell

James R. Caldwell, 33, has been named technical director of Resin Formulators, Inc., Los Angeles firm specializing in production of formulated epoxy resins.

In his new post, Caldwell will be responsible for all research, development and production for Resin Formulators. His program is aimed toward solving potting, encapsulating and coating problems of the electronics industry.

Before joining Resin Formulators, Caldwell was chief research engineer for Century Engineers, Inc., Los Angeles.

Carl S. Brown has been promoted to product development manager for Glascote Products, Inc., manufacturer of glass-coated steel pressure vessels for the chemical

processing industry. Brown is designer of the world's first glass-lined spherical chemical reactor, unveiled at the annual Exposition of the Chemical Industries in New York in December.

Byron J. Anderson

National Petro - Chemicals Corp. has named Byron J. Anderson as manager of its polyethylene plant which will be built in Houston, Tex.

A chemical engineering graduate of the University of Alberta, Anderson served as senior technologist at the Calgary, Alberta and Montreal refineries of Imperial Oil Co. from 1943 until 1952, when he joined National Petro-Chemicals.

He started as ethylene area superintendent and was serving as assistant chief technologist at National Petro-Chemicals, Tuscola, Ill., plant at the time of his appointment.

Robert R. Gumaer has been promoted to senior chemical engineer in the research and development department of American Oil Co.

Kenneth A. Dunbar has been appointed manager of the Atomic Energy Commission's Chicago Operations office at Lamont, Ill.

William R. Millard and **Lewis A. Barry** have been named department managers at Callery Chemical Co.'s research and development division. Millard will head the engineering department while Barry will be in charge of the development department.

Stuart G. McGriff

Appointment of Stuart G. McGriff as product manager, fuels and propellants, has been announced by Callery Chemical Co. McGriff will be in charge of marketing Callery's new high energy boron fuel, HiCal, and other fuels and propellants to the aircraft and missiles industry.

Prior to his new appointment, McGriff was head of economics and market research for Callery. At one time, he worked on liquid metals and oxygen generating equipment for Callery and Mine Safety Appliances Co. From 1949 to 1952 he was a technologist at the Wood River, Ill., refinery of Shell Oil Co.

J. Ranald Fox, works manager of the alumina plant at Alcoa's Point Comfort Operations since early 1956, has been named assistant general manager of the refining division.

William C. Uhl, former managing editor of the now defunct *Petroleum Processing,* is now technical editor in Esso Research and Engineering's technical information division. **Ralph F. Howe** has been appointed head of Esso Standard Oil Co.'s petroleum products division, Baton Rouge, La. And **Walter J. Porter, Jr.** has been named assistant head of catalytic research and development at Esso Research Laboratories in Baton Rouge.

Robert R. Gumaer has been promoted to senior chemical engineer in the research and

NAMES . . .

development department of American Oil Co. at Texas City, Tex.

Arnold M. Varner, long active in plastics engineering, has been appointed plant superintendent of Capac Industries' Michigan plant.

Lockwood W. Ferris has been named president of Bonneville Ltd., producers of prilled potash from solar evaporation.

Kenneth A. Mack

Baker Perkins, Saginaw, Mich., has named Kenneth A. Mack as vice president in charge of its chemical machinery division. Mack's new position embraces both sales and engineering. He will also retain his responsibilities as sales manager of the division.

Mack joined Baker Perkins in 1937 as a chemical engineer. Assignments which followed included supervision of chemical machinery experimental laboratory; assistant manager of chemical machinery division; sales manager of the chemical machinery division; director of the corporation.

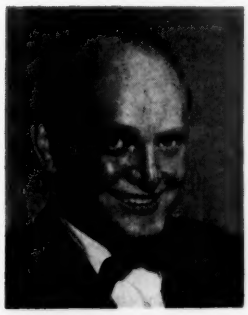
P. B. Mayfield, who started with Barrett Div., Allied Chemical & Dye Corp., as a consultant, is now manager of the division's industrial tar products sales.

John C. Bailar, Jr. has been chosen president-elect of the American Chemical Society and will head the organization in 1959.

George E. Holbrook

1958 president of the American Institute of Chemical Engineers is George E. Holbrook, general manager of Du Pont's elastomer chemical department.

Holbrook has been active in AIChE since 1934, serving as vice president, director, member and chairman of several committees. In 1953 he was awarded the 1953 Professional Progress Award in Chemical Engineering.



Myrle M. Perkins

Bechtel Corp., engineering and construction firm with headquarters in San Francisco, has announced the appointment of Myrle M. Perkins as executive engineer.

Perkins, widely known in the petroleum and chemical industries, will be active in business development, primarily in the refinery and petrochemical fields.

Before joining Bechtel, Perkins was associated with M. W. Kellogg Co. for 21 years.

W. H. Griest, Jr., has been appointed an assistant in Atlas Powder Co.'s economic evaluation department. Before

NAMES . . .

joining Atlas, Griest served as a chemical engineer with S. B. Penick & Co.

Willard F. Libby, commissioner of the U. S. Atomic Energy Commission, has won the 1958 Willard Gibbs Medal for his development of the "atomic time clock" method for dating geological age and for his discovery that tritium (radioactive form of hydrogen) could be used to trace meteorological and geophysical processes. The award, one of the highest honors in American chemistry, is sponsored by the Chicago Section of the American Chemical Society.

Albert E. Cleghorn

Succeeding Donald G. Rogers as president of National Aniline Division, Allied Chemical & Dye Corp., is Albert E. Cleghorn.

Cleghorn joined Allied in 1933 and served on the Head Office staff. In 1952 he went to National Aniline, serving as assistant to the president, vice president and, since 1954, executive vice president.

Following his graduation from Brooklyn Polytechnic Institute in 1928, Cleghorn taught in Long Island University's chemistry department. Later, he was a member of the operating staff of Foster D. Snell, Inc.

Bertram K. Denton will be vice president and a director of Monsanto Chemical Co.'s Japanese affiliate, Monsanto-Kasei Chemical Co., Tokyo. Denton was with the former foreign department of Monsanto at St. Louis for a period

in 1947, prior to assignment in India that year.

H. L. Payton has been appointed plant manager of Monsanto Chemical Co.'s Barton Plant, Luling, Pa. **F. B. Elliott** has been promoted to production superintendent at the Barton plant.

Joseph C. Weaver, Jr.

Joseph C. Weaver, Jr., formerly technical director of the Amoco Chemicals Corp. plant at Brownsville, Tex., has been named associate director of American Oil Co.'s research and development department.

In 1947, Weaver joined Stanolind Oil & Gas, which operated the Brownsville plant before creation of Amoco Chemicals Corp. He started as a chemical engineer assigned to the research department. Subsequently he was promoted to technical supervisor, chemicals plant, and assistant plant superintendent.

Weaver holds numerous patents in the fields of dye intermediate manufacture and hydrocarbon synthesis. He wrote the hydrolysis section of Kirk and Othmer's "Encyclopedia of Chemical Technology."

John L. Neenan, a past president of the International Institute of Milling Technology, has retired from his position of chemical processing and food machinery engineer with Allis-Chalmers Mfg. Co.

Norman L. Helgren has been named assistant manager of the Saltair, Utah, solar evapo-

ration plant of Morton Salt Co.

Russell L. Haden, Jr., a former executive of Dewey and Almy Chemical Co., has been named general manager of the chemicals division of Virginia-Carolina Chemical Corp.

Charles N. Kimberlin, Jr.

The Southern Chemist Award for his "outstanding career in the fields of catalysis and petroleum chemistry" was presented to Charles N. Kimberlin, Jr. on November 14.

Kimberlin, assistant director of Esso Research Laboratories, Baton Rouge, La., is known for advances touching nearly every phase of the petroleum industry —ranging over fields of isomerization, alkylation, industrial greases, fluid coking, catalytic reforming.

Starting as a research chemist with Esso Research in 1933, Kimberlin was named senior research associate before being appointed an assistant director in 1954. He holds 83 U.S. and numerous foreign patents.

OBITUARIES

Frank E. Richardson, of Shreveport, one of the world's foremost pipeline and oil refinery consulting engineers, died December 3 at a local hospital following a lengthy illness.

Clair O. Evans, who had been associated with Phelps Dodge Copper Products Corp. for 41 years, died December 8 in New York City after a long illness. He was 64 years old.

PEOPLE . . . FIRMS IN

NEW NAMES

Haydon Div. of General Time Corp. is the new title of Haydon Manufacturing Co., builder of timing motors.

Pecora, Inc., has been adopted as new name of Pecora Paint Co. because of increasing activity in fields other than paint.

Refractories Div. of Carborundum Co. now takes in all operations of company's former Stupakoff Div., Globar Div. and Refractories Div.

Food & Drug Research Laboratories is new name of Food Research Laboratories. It's now located at Maurice Ave. at 58th St., Maspeth 78, New York.

Monogram Precision Industries is now the name of International Glass Corp., Culver City, Calif.

NEW COMPANIES

Drexelbrook Consulting Service has been organized to offer aid on engineering problems in instrument, automation and control fields.

Cyanamid-Ketjen N. V. has been formed jointly by American Cyanamid and Koninklijke Zwavelzuurfabrieken v/h Ketjen N. V. of Amsterdam, Holland. Company will manufacture platinum reforming catalysts for the oil industry.

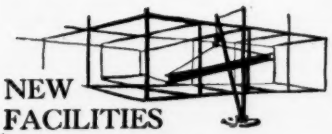
Single Crystal Corp. of America, Saxonburg, Pa., is now producing single crystals of various materials for electronic,

optical and nuclear applications.

Holex Inc. is a new engineering and production organization entering the field of explosive ordnance and related devices. Headquarters is in Hollister, Calif.

Vitro International, a new Vitro operating company with headquarters in Switzerland, will represent all Vitro operations overseas.

Armstrong Contracting & Supply Corp. is being formed by Armstrong Cork Co. to handle all contracting operations now carried on by its Insulation Div.



NEW FACILITIES

Firestone Tire & Rubber Co. has opened its $10-million butadiene plant at Orange, Tex. Plant supplies raw material for company's synthetic rubber operations.

Reichhold Chemicals plans to erect a chemical plant at Hampton, S. C. First portion completed will be a 30-million-lb./yr. formaldehyde unit slated to be in production by July 1958.

Monsanto Chemical Co. is now building a 100-ton/day urea plant at El Dorado, Ark. Installation, scheduled to be on stream by early fall, will make urea in both prill and solution forms.

Boise Cascade Corp. is building a multimillion-dollar pulp, paper and container production facility on a 157-acre site at Attalia, Wash. Container plant will be in operation by spring 1958, pulp and paper

FIRMS . . .

mill will be completed in 18-24 months.

Brush Beryllium Co. is operating its new beryllium metal plant at Elmore, Ohio. Unit turns out 10,000 lb./mo. vacuum-cast ingots.

Stauffer Chemical Co. has upped capacity of its San Francisco boric acid plant by 50%. Cost of expansion was about $500,000.

American Petrofina Co. of Texas has contracted with J. F. Pritchard & Co. for construction of a platformer and alkylation unit at the Mount Pleasant, Tex., refinery. Cost totals $2 million and company plans to spend an additional $850,000 on other refinery improvements.

Yuba Consolidated Industries, San Francisco, has established a research and development center for developing new products and new applications for its equipment in the heat-transfer field.

Rockwell Manufacturing Co.'s new $2-million valve plant at Kearney, Neb., is now in operation. The 180,000-sq.-ft. facility employs 75 workers.

Carter Oil Co. is boosting capacity of its Billings, Mont., refinery from 25,000 bbl./day to 34,000 bbl./day crude by modifying existing equipment. Program will cost $1.5 million.

Wallingford Steel Co. has added a new metallurgical laboratory to its quality control facilities at company's Wallingford, Conn., plant.

Wagner Electric Corp. expanded its St. Louis, Mo., plant with an addition of 28,000 sq. ft. to present manufacturing facilities.

Firth Sterling is now operating its new tungsten carbide sintering facilities at Los Angeles. Plant makes semi-standard and special shapes previously manufactured in the East.

. . . a critical place to safeguard your reputation with "TUBE-TURN" products

Stainless steel piping is a specialist. It fights corrosion . . . prevents product contamination . . . performs under great temperature extremes . . . is able to handle dangerous materials safely. Construction and maintenance dollars, often the safety of life and property, and *your reputation* are at stake in the selection of these materials.

When you specify TUBE-TURN* Stainless Steel Fittings and Flanges, you get extra-value features and greater strength at no extra cost. Fittings are marked with *complete* identification. Production procedures and quality control assure conformity to all code requirements.

Your nearby Tube Turns' Distributor can meet *all* your needs in welding fittings and flanges *promptly.*

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

TUBE TURNS LOUISVILLE 1, KENTUCKY

A Division of National Cylinder Gas Company

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle

In Canada: Tube Turns of Canada, Ltd., Ridgetown, Ontario • Toronto, Ontario • Edmonton, Alberta • Montreal, Quebec • Vancouver, B.C.

YOUR SAFEGUARDS

You get these extra values at no extra cost with

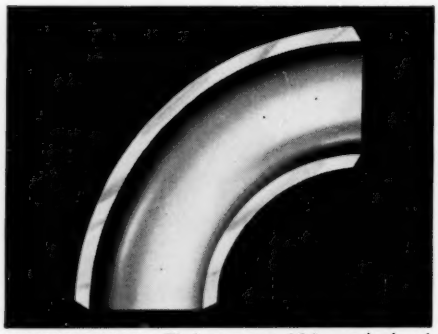
TUBE-TURN

Stainless Steel Fittings

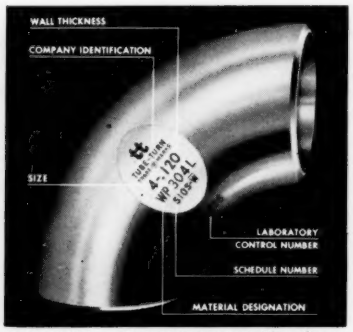
- Fittings meet *all* standard chemistry specifications
- Minimum wall thickness of elbows are at least 87½% of nominal
- All fittings meet calculated bursting pressure of matching pipe
- Qualified welders and procedures used where welding is required
- Each fitting properly solution heat-treated
- Each fitting passivated
- Special grades of stainless steel, and all other alloys available

Meet all codes: ASTM A403 (for material and manufacturing procedure); MSS SP43 and ASA B16.9 (for dimensions); and MSS SP25 (marking procedure).

TUBE-TURN Stainless Steel Elbows and Tee in a petrochemical plant.



UNIFORM WALL. Fittings meet ASA standards of 87½% of nominal thickness . . . particularly important for light wall elbows. Many conventional stainless steel elbows are as much as 30% to 40% below nominal at this point of greatest wear. All TUBE-TURN® Stainless Steel Fittings, including tees, match calculated bursting strength of the pipe.



COMPLETE IDENTIFICATION. You *know* this fitting conforms to specified quality because the material type and quality control are fully identified. Manufacturer, size, wall thickness and schedule are also marked as shown on the fitting.

CUTS PURCHASING COSTS. You can order TUBE-TURN Stainless Steel Fittings from your nearby Tube Turns' Distributor . . . on the same order as other types of welding fittings in Tube Turns' line of 12,000 products. Cuts red tape. Saves time. Photo courtesy McJunkin Corporation, Charleston, W. Va.

TUBE TURNS, Dept. H-1
224 East Broadway, Louisville 1, Kentucky
Please send STAINLESS STEEL CATALOG.

Company Name_____

Company Address_____

City_____ Zone_____ State_____

Your Name_____

Position_____

Available from your nearby TUBE TURNS' Distributor

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland • Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle. **IN CANADA:** Tube Turns of Canada Ltd., Ridgetown, Ontario • Toronto, Ontario • Edmonton, Alberta • Montreal, Quebec • Vancouver, British Columbia.

Allied Chemical & Dye Corp.'s General Chemical Div. will build a sulfuric acid plant at Anacortes, Wash., to serve adjacent Shell refinery. Unit will include modern spent-acid decomposition facilities.

Pennsalt Chemicals Corp. has announced plans for a $10-million chemicals plant near Vancouver, B. C., which will supply Canada's growing pulp and paper industry.

Perry Equipment Corp., Philadelphia, Pa., has opened a New York City office for handling company's complete line of process equipment.

Guardian Paper Co., producer of plastic-coated paper, boosted capacity to 1 million lb./mo. when it moved into a new plant at Newark, Calif.

Parke-Davis will spend $500,000 building a new branch office and warehouse building on a 3-acre site in Skokie, Ill.

Shell Oil's refinery at Stanlow, England, is getting a $2.2-million Udex aromatic extraction unit, will produce aviation gasoline blending components.

British Oxygen Gases, Ltd., is erecting a new liquid oxygen plant at Crawley, Eng., slated for completion in 1959. Facilities for acetylene production may be installed later.

Abbott Laboratories is constructing five new buildings on its Mundelein, Ill., farm for use in its expanded agricultural research program.

Shell Development Co. has begun construction of a new process development laboratory at Emeryville, Calif. The $500,000 installation, containing 10,000 sq. ft., will work up processes on pre-pilot plant scale.

Farbenfabriken Bayer, German chemical manufacturer, is operating a new 50-ton/day titanium dioxide pigment plant in Uerdingen. Facility cost $14.3 million; already planned is a $9.5-million ex-

pansion to up capacity to 150 tons/day of white pigment.

Macalaster-Bicknell Co., Cambridge, Mass., manufacturer of laboratory and industrial supplies, has opened a new glass plant in Fitzwilliam, N. H.

Monsanto Chemical Co. and Carbometal S.A.I.C. of Mendoza, Argentina, are planning to manufacture vinyl chloride monomer and polyvinyl chloride at a new plant to be built in Mendoza.

Metalab Equipment Co. has opened a new 48,000-sq.-ft. plant at Elkins, W. Va., which will manufacture wood laboratory equipment.

Nopco Chemical Co.'s Richmond, Calif., plant is now on stream making a complete line of wax sizes, expanding company's paper chemicals operations on the West Coast.

Air Reduction Co. recently completed a $400,000 gas-producing plant at Arlington, Tex. Facility turns out high-purity oxygen and nitrogen and has storage for acetylene, argon and calcium carbide.

American Cyanamid Co. is well along on construction of its $4.5-million secondary sewage treatment plant being erected next to its Bound Brook, N. J., facilities. Completion is slated for April 1958.

Canadian Industries Ltd. is now producing carbon tetrachloride in a new plant at Cornwall, Ont. Unit, utilizing carbon bisulfide-chlorine reaction, is part of CIL's three-year expansion program.

Beckman Instruments is well underway on construction of a $250,000 manufacturing plant at Glenrothes, Scotland, which will house company's newly formed subsidiary, Beckman Instruments Ltd.

Sinclair Refining Co. is installing an MEK dewaxing-deoiling unit at its East Chicago,

Ind., refinery. Unit, slated for operation late in 1958, is being erected by Badger Manufacturing Co. and is similar to the plant Badger is building for Atlantic Refining Co.

Standard Oil Co. (Ind.) has a new lubricating oil plant operating at its Casper, Wyo., refinery. Capacity of the unit is 800 bbl./day finished lube oil.

Consolidated Water Power & Paper Co. has installed a new boiler and steam turbine plant as part of a $15-million expansion at Wisconsin Rapids, Wis. Producing 250,000 lb./hr. steam at 1,450 psig., boiler is one of highest pressure units used in pulp and paper industry.

Celanese Corp. of America is building a new manufacturing plant at its Belvidere, N. J., location to increase production of polyvinyl acetate emulsions, used in water-thinned latex paints, adhesives, non-woven fabrics and coatings.

Bradford Laboratories, oil field water consulting firm, has opened a new regional office-laboratory in Abilene, Tex.

Shell Development Co. has completed a $1-million expansion at its Modesto, Calif., laboratory where all its agricultural research facilities are being consolidated.

NEW LOCATIONS

Pilot Chemicals has moved its plant and offices to 36 Pleasant St., Watertown, Mass.

Taylor Fibre Co. has relocated its New England branch office at 967 Farmington Ave., West Hartford, Conn.

Foster Wheeler Corp. has moved its offices to new

FIRMS . . .

quarters at 666 Fifth Ave., New York, N. Y.

Tipptronics, Inc., manufacturer of electronic controls, has transferred operations to Chagrin Falls, Ohio.

NEW REPRESENTATIVES

Case-Orians Co., Detroit, Mich., is the newly appointed eastern Michigan representative for McQuay heating, air conditioning and refrigeration equipment.

MERGERS & ACQUISITIONS

Imperial Paper & Color Corp. (Canada) is taking over the dry color operations of Sherwin-Williams Co. of Canada.

Gaylord Products, Chicago, has acquired the complete assets of two hair accessory companies—the Mervin Wave Clip Co. and the Smith Victory Corp. of Buffalo.

Cohu Electronics has acquired two eastern companies—Millivac Instrument Corp. and Volkers & Schaffer. Both companies are located in Schenectady, N. Y.

DeVilbiss Co., Toledo, Ohio, manufacturer of spray-painting equipment, has expanded into South American market with purchase of controlling interest in Matrix, S. A., a manufacturing firm in Sao Paulo, Brazil.

Pfaudler Co., manufacturer of glass-lined steel vessels, and Permutit Co., manufacturer of water-treating equipment and chemicals, have merged. New firm will be known as Pfaudler-Permutit Inc.

Getting more service hours per dollar

HOW TO BUY FLEXIBLE METAL HOSE

3 simple steps can help you select metal hose for best results and longer service life

The important job of selecting the *most economical*, the *one right* flexible metal hose for your product or transfer problem can be greatly simplified by following these 3 steps:

1 Send exact specifications

Complete and exact statement of operating conditions will go far in saving you money on flexible metal hose.

First, it assures you that the connector you get will live up to your expectations. And, second, that manufacturers won't bid on hose that's "over-engineered." You'll save in the long run because you'll get the right assembly for every job.

Here is the information we need before we can give you our best suggestions:

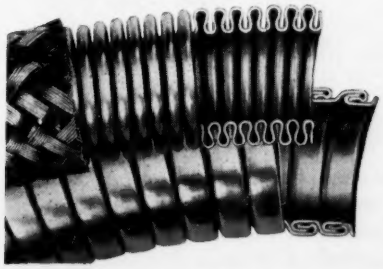
A PHYSICAL REQUIREMENTS:

1) *Over-all length (including fittings)*
2) *Diameter (I.D. and O.D.)*
3) *Fittings—size, type, style of thread*
4) *Tolerances permitted*
5) *Quantity required*

B OPERATING REQUIREMENTS:

1) *Material to be conveyed*
2) *Operating pressures—is there shock?*
3) *Operating temperatures*
4) *Movement—lateral and longitudinal*
5) *Vibration conditions?*
6) *Expansion and contraction requirements?*
7) *Corrosive atmosphere?*

Send sketch of proposed installation if available.



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CORRUGATED and STRIP-WOUND. In a wide range of sizes and styles in any workable metal: Bronze, Brass, Aluminum, Stainless Steel. Various fittings.

2 Use standard metal hose where possible

Many standard connectors have been developed to meet problems common to many finished products—i.e., vibration. Often a standard metal hose will answer your needs as well as a special item could. We can often save you money if we know operating requirements.

3 Call the Man from Anaconda to help you select, specify, test

When selecting or specifying flexible metal hose, you'll find American's staff of trained engineers of invaluable assistance. Their advice and suggestions may help you solve or avoid many costly problems.

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BASIC RESEARCH . . .
More Practical Than You Think

This editorial, one of a special series on the importance of research to the American economy, deals with an aspect of our research program that may have serious consequences in future years — the lag in basic research.

An earlier editorial in this series noted: "The keen interest of U. S. business firms in scientific research points the way to a new kind of prosperity for our economy — a prosperity based on deliberate creativeness." As a result of the dramatic increase in industry's research expenditures, more new products will be introduced in the years 1957-1960 than in any previous four-year period.

A steady stream of new products and new processes means better values for consumers and lower costs for business. And thus it promises to sustain a high level of general prosperity that defies the old laws of boom and bust. **But, as we look further ahead, there is a danger that the stream of research discoveries may run dry because of our neglect of basic research.**

This danger was described by John Jay Hopkins, late founder and chairman of the General Dynamics Corporation: "Unless there is a revolutionary development in America of pure, not applied, science, there will come a day when there is no use in trading in your old car; because the new one is no better. The only difference between this year's television set and next year's will be the appearance of the cabinet! Scientific progress will be replaced by scientific stagnation."

What Basic Research Is

Basic (or pure) research has been characterized as the pursuit of knowledge for its own sake rather than to fulfill some practical objective. It is generally carried out in an environment which allows the investigator the freedom to follow the lead of his curiosity. The scientist in basic research, in the words of Glenn T. Seaborg of the University of California, is not concerned with "utilitarian goals, but a search for deeper understanding of the universe and the living and inorganic phenomena within it."

Impractical as basic research may seem in its initial purpose, it is an essential prerequisite to applied research and product development. A few examples will show how some of the greatest technical advances of recent years have come from basic research projects that had no immediate practical objective:

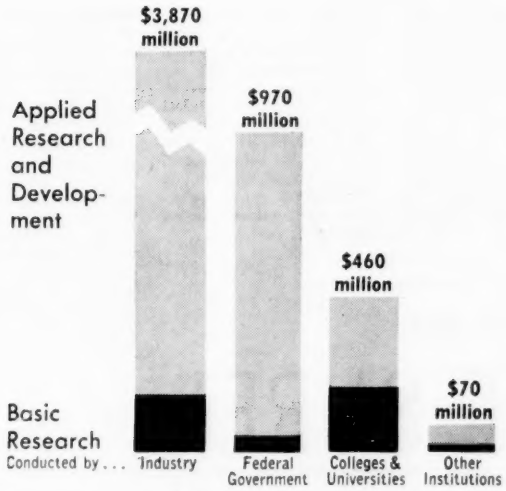
- **Radar** — an important military development of World War II with broadening commercial applications — was the outgrowth of a basic research project whose purpose was to obtain information about the height of the ionosphere, the layer of air that lies some 25 miles above the earth's surface.

- **Transistors** — the miniature devices which are already vital components of hearing aids, pocket radios and a wide variety of industrial equipment — were invented at Bell Laboratories (research subsidiary of the American Telegraph and Telephone Company) following university investigations into the electrical behavior of solids.

- **Neoprene** — a synthetic rubber — was developed by duPont with the help of basic information provided by Father Nieuwland of Notre Dame, who discovered he could control the polymerization (the linking together of molecules) of a certain class of organic compounds.

- **Nylon** — the first of the noncellulosic synthetic fibers that have revolutionized the textile industry — grew out of fundamental research by Dr. Wallace Carothers on long-chain polymers.

Only 8% of All Research and Development in the U. S. is Devoted to Basic Research



Data: National Science Foundation, "Funds for Basic Research in the United States, 1953"

Industry's Stake in Basic Research

Industry traditionally has relied upon colleges and universities and other nonprofit institutions for basic research; and the U. S. has long benefited from the greater emphasis placed on basic research in Europe. It is conventional to think that business cannot, and should not, do much about "ivory tower" projects which do not have immediate practical application.

However, there is not so much in this idea as is supposed. The examples above illustrate what Caryl Haskins, president of the Carnegie Institution, has called "the widespread paradox that the most important practical consequences are commonly the least sought after." Furthermore, it is certain that, without adequate basic research, industry's efforts to produce new and better products will become progressively more difficult. And our national defense, in an age of breathtaking military applications of science, will become increasingly precarious.

In the past, our economic growth came largely through expansion into new lands or through discovery and development of rich deposits of natural resources. Such opportunities are relatively limited today. The great opportunities now lie in discovering new materials and new properties of the materials we already have. **This is the job of basic research, and industry has a vital stake in it.**

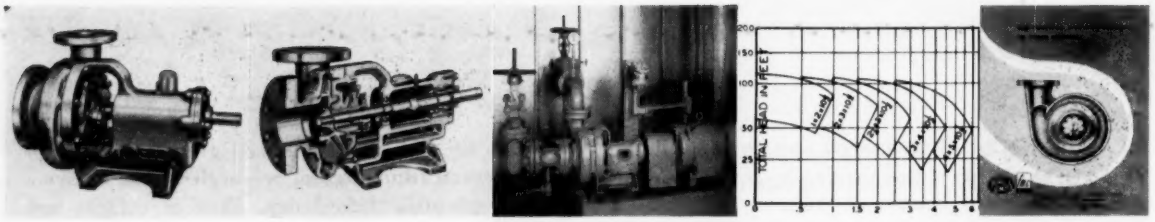
The chart indicates the tiny share of research efforts in the U.S. that is devoted to basic research. **Only 4% of all research by industry, and only 8% of all research in the U.S., during the year 1953** (the latest for which information is available) **represented fundamental research to add to overall scientific knowledge.** Even in colleges and universities less than half the research performed is basic research. At least one Nobel Prize winner has expressed the belief that we need and should work toward a doubling of the proportion of our total research effort that is devoted to basic research as soon as possible.

What Business Can Do

Without anything like a staggering increase in the total cost of its research programs, industry could do much to expand our basic research effort. Companies with big research programs should, as a matter of successful survival, be devoting a share of the effort in their own laboratories to basic research. Significantly, companies that are already doing a notable job of basic research have also made an outstanding record of translating such research into new products for industry and the consumer.

Smaller companies may rightly regard the conduct of research projects with uncertain prospects of reward as a luxury. Some basic research, indeed, never results in any tangible payoff. But, with modest contributions, small companies can still have a part in the advance of basic research. They can join together with other companies on cooperative projects. They can support basic research through trade associations and technical societies. They can help research centers in universities and other nonprofit institutions. Arrangements are available in some instances whereby business firms can pay a fee to have access to work done by university researchers.

One way or another, it is up to private business firms to see that basic research moves forward. By doing so they will be laying the groundwork for the development of the new products and technology on which their growth, and the growth of the economy, depend.



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OFFER optimum performance range, you benefit from the economical performance only the exact pump for the job can give you. The Peerless process pump line of over 78 models, sizes and frames, plus thousands of combinations, assures you of pinpoint pump selection that effects direct savings in cost.

EMBODY benefits of research in all areas of design, construction, and application. Typical of the many considerations in the design and manufacture of a Peerless pump is the ascertaining of effects of radial loads. **An interesting 8 page booklet discussing this phase of pump design is available to you upon request.**

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4	24-3	33-4i	42	63	78G	86D	151	177	B188	198O	200F	200V	201N	202K	202AA	203P	204N
6-7	26	33-4j	43	65	78H	87	153	177a	189	198P	200G	200W	201O	202L	203A	203Q	204O
8-9	27	33-4k	44	67	78I	89	154	178	197	198Q	200H	200X	201P	202M	203B	204	204P
10-1	28	33-4l	45	69	78J	92	156	179	198A	199	200I	201A	201Q	202N	203C	204A	204Q
10-1a	29	33-4m	45a	71	79	92a	159	180	198B	199A	200J	201B	201R	202O	203D	204B	206
10-1b	30	33-4n	45b	73	80A	92b	163	181	198C	199B	200K	201C	201S	202P	203E	204C	212
10-1c	31	33-4o	45c	74A	81	92c	165	181a	198D	199C	200L	201D	202A	202Q	203F	204D	213
10-1d	32	33-4p	45d	75	82A	92d	166	181b	198E	199D	200M	201E	202B	202R	203G	204E	214
10-1e	33-4	33-4q	45e	76A	82B	92e	167	181c	198F	199E	200N	201F	202C	202S	203H	204F	214a
12	33-4a	33-4r	45f	76B	83	97	168	181d	198G	199F	200O	201G	202D	202T	203I	204G	214b
13	33-4b	33-4s	46	77	84A	102	169	182	198H	199G	200P	201H	202E	202U	203J	204H	214c
14	33-4c	35	47	78A	84B	106	170	183	198I	199H	200Q	201I	202F	202V	203K	204I	214d
15	33-4d	36	49	78B	84C	143	172	184	198J	200A	200R	201J	202G	202W	203L	204J	214e
16-7	33-4e	37	50	78C	85	145	173	184AB	198K	200B	200S	201K	202H	202X	203M	204K	214f
18-9	33-4f	39	52	78D	86A	146	174	185	198L	200C	200T	201L	202I	202Y	203N	204L	214g
20-1	33-4g	40	57	78E	86B	147	175	187	198M	200D							

REPRINTS: Circle what you want. See p. 206 for descriptions.

4 21 22 25 26 28 33 35 36 37 38 40 42 45 46 47 48 49 50 52 54 55
56 57 59 61 62 63 64 65 66 67 68 69 70 72 73 74 75 76 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 104
106 107 108 109 111

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CODE NUMBERS ARE PAGE NUMBERS and the letters identify specific products on a page—a, b, c, etc. for ads; A, B, C, etc. for editorial items. And to locate an ad; T (top), B (bottom), R (right), L (left). The index below is a guide for advertising pages showing more than one item.

Important—For pages showing more than one advertised item use this guide to numbers on cards above.

10-1 All items discussed
- 10-1a Dryer-blenders
- 10-1b Pumps, glassed
- 10-1c Reactors, glassed steel
- 10-1d Steel, glassed, bulletin 947
- 10-1e Steel, glassed

33-4 All items discussed
- 33-4a Dextro propoxyphene
- 33-4b Riboflavin
- 33-4c Ester mixtures
- 33-4d Sorbitol
- 33-4e Polyethylene compound
- 33-4f Ceramic textiles
- 33-4g Paper, acrylic
- 33-4h Soda, caustic
- 33-4i Titanium
- 33-4j Reactors, research
- 33-4k Pens, marking
- 33-4l Fuel oil additives
- 33-4m Biochemicals
- 33-4n Hydrazine derivatives
- 33-4o Microscopy
- 33-4p Acid, isocinchomeronic
- 33-4q Heaters
- 33-4r Acid inhibitor
- 33-4s Drainage systems

45 All items discussed
- 45a Potash, caustic
- 45b Sodium sulfide
- 45c Sodium sulfhydrate
- 45d Lubricants
- 45e Sodium chlorate
- 45f Chemicals, bulletin 100-A

92 All items discussed
- 92a Filters, vertical leaf
- 92b Filters, vertical batch
- 92c Filters, horizontal leaf
- 92d Filters, horizontal batch
- 92e Filters, cartridge

177 All items discussed
- 177a De-airing machines, bulletin H1

181 All items discussed
- 181a Coils, heating & cooling
- 181b Towers, cooling
- 181c Condensers, evaporative
- 181d Dehumidifiers

214 All items discussed
- 214a Mixers, top entering, bulletin B-102
- 214b Mixers, top entering, bulletin B-103
- 214c Mixers, portable
- 214d Mixers, side entering
- 214e Mixers, laboratory
- 214f Mixers, bulletins B-109 & B-107
- 214g Seals, rotary

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8-9	27	33-4k	44	67	78I	89	154	178	197	198Q	200H	200X	201P	202M	203B	204	204P
10-1	2P	33-4	45	69	78J	92	156	179	198A	199	200I	201A	201Q	202N	203C	204A	204Q
10-1a	29	33-4m	45a	71	79	92a	159	180	198B	199A	200J	201B	201R	202O	203D	204B	206
10-1b	30	33-4n	45b	73	80A	92b	163	181	198C	199B	200K	201C	201S	202P	203E	204C	212
10-1c	31	33-4o	45c	74A	81	92c	165	181a	198D	199C	200L	201D	202A	202Q	203F	204D	213
10-1d	32	33-4p	45d	75	82A	92d	166	181b	198E	199D	200M	201E	202B	202R	203G	204E	214
10-1e	33-4	33-4q	45e	76A	82B	93e	167	181c	198F	199E	200N	201P	202C	202S	203H	204F	214a
12	33-4e	33-4r	45f	76B	83	97	168	181d	198G	199F	200O	201Q	202D	202T	203I	204G	214b
13	33-4b	33-4s	46	77	84A	102	169	182	198H	199G	200P	201H	202E	202U	203J	204H	214c
14	33-4c	35	47	78A	84B	106	170	183	198I	199H	200Q	201I	202F	202V	203K	204I	214d
15	33-4d	36	49	78B	84C	143	172	184	198J	200A	200R	201J	202G	202W	203L	204J	214e
16-7	33-4a	37	50	78C	85	145	173	184AB	198K	200B	200S	201K	202H	202X	203M	204K	214f
18-9	33-4f	39	52	78D	86A	146	174	185	198L	200C	200T	201L	202I	202Y	203N	204L	214g
20-1	33-4g	40	57	78E	86B	147	175	187	198M	200D							

REPRINTS: Circle what you want. See p. 206 for descriptions. 4 21 22 23 26 28 33 35 36 37 38 40 42 45 46 47 48 49 50 52 54 55 56 57 59 61 62 63 64 65 66 67 68 69 70 72 73 74 75 76 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 104 106 107 108 109 111

Key to Tomorrow's Problems

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COMPLETE PRODUCT INDEX of chemicals, materials, equipment and services taken from this issue's advertisements and new products departments. You can get more information on any item by circling its code number on one of your Reader Service postcards.

Chemicals

Acid inhibitor, TD1319 ..... 33-4r
Acids
  Base detergent 78H
  Isocinchomeronic, TD1317 ..... 33-4p
  Propionic 198A
Ammonia, anhydrous 198B
Ammonium sulfate 57
Anthracene 78I
Anti-caking agent 198C
Antifoam 198D

Beryllium oxide 198E
Biochemicals, TD 1314 ..... 33-4m
Bleaching process 198F
Brominated compounds 78D
Butadiene 198G

Calcium carbonate 198H
Carbon, activated 78A
Cement, epoxy resin 198I
Chemicals 33-4., 45, 2, 30, 145
  Bulletin 100-A 45f
Copper sulfate 198J
Corrosion inhibitor 198K

Descaler-deruster 198L
Dextro propoxyphene 33-4a

Ester mixtures 33-4c

Fuel oil additives, TD1313 ..... 33-4l

Geraniol 78F
Glass fiber 78J
Gramicidin 198M

Hydrazine derivatives, TD1315 ..... 33-4n
Hydrogen peroxide dilution 198N

Laminate system 198O
Lubricants 45d

Magnesium methoxide 78B
Methallyl acetate 78C
Mica, wet ground 198P
Molding compound 198Q
Monomers 199A

Neopentyl glycol 199B
2-Nitropropane 199C

Ozone 182

Paint, acrylic 199D
Pigments, metallic oxide 165
Plasticizer, rubber 199E
Polycarbonate plastic 199F
Polyethylene compound 33-4e
Polyethylene film 199G
Potash, caustic 45a

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TECHNICAL LITERATURE

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Chemicals

Acid Inhibitor.....New acid inhibitor can, it is said, be used on high carbon steel without etching. Used at about 0.2% by volume, added to non-oxidizing acids such as sulfuric, hydrochloric, etc.
33-4r *U. S. Industrial Chem. Co.

Acid, Isocinchomeronic.....Isocinchomeronic acid, suggested intermediate for drugs, insecticides, polymers, dyes, is offered commercially. Ring-nitrogen may increase dye receptivity. TD 1317.
33-4p *U. S. Industrial Chem. Co.

Acid, Propionic.....4 p. bulletin on propionic acid includes data on physical properties, specifications, shipping data and applications (e.g., mold inhibitors, pharmaceuticals, solvents, plasticizers).
198A Union Carbide Chem. Co.

Ammonia, Anhydrous.....Illustrated bulletin discusses refrigeration grade anhydrous ammonia, including specifications, applications, equipment, installation and service. Request a copy.
198B Henry Bower Chem. Mfg. Co.

Anti-Caking Agent.....Technical service bulletin describes Zeolex (precipitated sodium silico aluminate) as an anti-caking agent for conditioning sugar. Includes table of compound's physical properties.
198C J. M. Huber Corp.

Antifoam.....Factual information sheet describes properties and applications for Hodag Antifoam TBX. Compound is designed especially for coatings and adhesives as an antifoam and leveling agent.
198D Hodag Chemical Corp.

Berryllium Oxide.....8 p. folder describes Berylco beryllium oxide, refractory oxide with unusually high thermal conductivity coupled with high electrical resistivity and dielectric strength.
198E Beryllium Corp.

Biochemicals.....Over 1,500 assayed biochemical compounds, along with their full specifications, are listed in a reference guide for bacteriological, nutritional, biological research workers.
33-4m *U. S. Industrial Chem. Co.

Bleaching Process.....Technical booklet describes activated hydrogen peroxide bleaching process for cotton. Discusses operating details, commercial application and savings in chemicals cost.
198F Solvay Process Div.

Butadiene.....52 p. technical manual on butadiene contains specifications, physical and chemical properties, chemical reactions, reactants and reaction products, end uses and bibliography.
198G Texas-U. S. Chemical Co.

Calcium Carbonates.....“Diamond Precipitated Calcium Carbonates in Neoprenes” illustrates range of properties obtainable with these carbonates when used as fillers in neoprenes. 11 p.
198H Diamond Alkali Co.

Cement, Epoxy Resin.....Technical Bulletin No. 23 describes Aluminum Metalset A4, a 2-component system. Resin part must be mixed with its hardener just before use. Used on metal and wood.
198I Smooth-On Mfg. Co.

Chemicals.....Company offers a free catalog of Shell solvents, resins and intermediates entitled “Organic Chemicals”. Solvents described include high-boiling EAK, ethyl amyl ketone.
2 *Shell Chemical Corp.

Chemicals.....Free 16-p. booklet lists the many chemicals available from Harshaw, including fluorides, glycerine, catalysts, synthetic optical crystals, agricultural chemicals, fungicides, etc.
30 *Harshaw Chemical Co.

Copper Sulfate.....Brochure describes manufacture of salt in modern plant; gives statistics on quantities used in industry, agriculture, export; describes and details specifications of grades produced.
198J Republic Chemical Corp.

Corrosion Inhibitor.....New 6 p. folder describes improved corrosion inhibitor for closed circulating water systems. Drawings illustrate use in various industrial applications.
198K Hagan Chemicals & Controls.

Descaler-Deruster.....Service report describes properties and uses of Oakite Drycid, powdered acid scale and rust remover. Recommended solution concentrations, application methods are given.
198L Oakite Products.

Fuel Oil Additives.....New fuel oil additives to prohibit gum formation in oil stocks are fatty amine derivatives claimed also to protect against color degradation and help filterability.
33-4I *U. S. Industrial Chem. Co.

Gramicidin.....20 p. review covers recent clinical literature on Gramicidin, constituent which accounts for accepted therapeutic activity of Tyrothricin (used in respiratory infections).
198M S. B. Penick & Co.

Hydrazine Derivatives.....Three new hydrazine derivatives, hydrazine dihydrochloride, hydrazodicarbonamide and monohydrazinium phosphate, are available in laboratory quantities. TD 1315.
33-4n *U. S. Industrial Chem. Co.

Hydrogen Peroxide Dilution.....Booklet includes dilution formulas for 27½%, 35%, 50% hydrogen peroxide, information on containers, stability tests and analysis of dilute solutions and dilution charts.
198N Solvay Process Div.

Laminate System.....Glasell brand flexible laminate system is combination of liquid resins and woven glass cloth. Provides shock resistant, chemically resistant surface.
198O Twinsburg-Miller Corp.

Mica, Wet Ground.....Technical Bulletin No. 33 deals with “Further Studies on the Use of Wet Ground Mica in Traffice Paints.” Bulletin is a continuation of Technical Bulletin No. 30.
198P Wet Ground Mica Assn.

* From advertisement this issue

Contents of This Issue . . .

Molding Compound.....Bulletin 113, 2 p. data sheet, describes Speediset plastic molding compound, new single component thermo-setting plastic used in making molds for casting cold setting plastics.
198Q . Technion Design & Mfg. Co.

Monomers.....1 p. flyer describes company's three vinyl monomers for the development of better emulsion paints, adhesives, coatings, finishes, laminates, plastics, synthetic rubbers.
199A Celanese Corp.

Neopentyl Glycol.....Technical data booklet covers various applications and derivatives of neopentyl glycol, including polyurethane foams, monoesters, and as a modifier of alkyd resins.
199B Eastman Chemical Products.

2-Nitropropane.....Data sheet describes physical properties and theoretical performance characteristics of 2-nitropropane. Compound is potentially valuable rocket propellant.
199C Commercial Solvents Corp.

Ozone.....Ozone solves the problem of toxic waste disposal, leaving no poisonous residual. It has many other chemical process applications. Request booklet on ozone generation.
182 *Welsbach Corp.

Paint, Acrylic.....“What You Should Know About Acrylic Latex Paints” describes the growth and uses of acrylic latex paints in the four years since they were first introduced. 8 p.
199D Rohm & Haas Co.

Plasticizer, Rubber.....3 p. bulletin covers use of Chlorowax 70 as a plasticizing and reinforcing resin in neoprene compounds. Major advantages when used with Type W and Type GN neoprenes are summarized.
199E Diamond Alkali Co.

Polycarbonate Plastic.....Comparative properties of GE's Lexan polycarbonate resin and other thermoplastic molding materials are outlined in “Plastics Properties Chart” (CDD-5).
199F General Electric Co.

Polyethylene Film.....16 p. booklet, “Heat Seal Characteristics of Polyethylene Film,” discusses prime conditions within which satisfactory heat seals can be made. Illustrated with 40 graphs.
199G U. S. Industrial Chemical Co.

*From advertisement, this issue.

For the latest developments in

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Soil Fumigant.....New folder explains how to use a new, powdered soil fumigant that needs no plastic cover. Called Crag Mylone, it also acts as a herbicide and nematocide in pre-planting treatments.
199H Union Carbide Chemicals Co.

Urethane Modifiers.....24 p. technical bulletin, "Castor Oil Products for Urethane Polymers" discusses over 20 derivatives of castor oil currently or potentially useful in urethane modifications.
200A Baker Castor Oil Co.

Zirconium.....'Technical Digest on Commercial Grade Zirconium" describes applications and properties of this grade of Zr. Also reviews corrosion and physical properties, fabrication methods.
200B Columbia-National Corp.

Construction Materials

Coating, Protective.....Mono-Seal is tough, plastic coating formulated from special blend of silicones and epoxies; contains no plasticizer or oils. Bulletin describes applications, drying times.
200C Mono-Seal Products.

Coatings, Protective.....Ceilcote E-900 is a protective coating for structural steel, tanks, stacks, etc. It resists a variety of chemicals and can be applied by brush or roller. Bul. E-900.
180 *Ceilcote Co.

Construction Equipment.....8 p. bulletin, CG-15, describes line of construction equipment including air compressors, air tools, breakers, drills, tampers and spades; one-use drill bits.
200D LeRoi Division.

Fabrication.....Company offers their Plant Survey Report No. 4, a comprehensive report on Nooter facilities for fabrication. High quality, careful inspection and dependable schedules.
81 *Nooter Corp.

Fabrication.....Standard and custom-engineered metal products made by Boardman are in use throughout the chemical process industries. Request booklet, "Working With Metal at Boardman".
178 *Boardman Co.

* From advertisement this issue

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Insulation, Pipe.....Complete specifications for company's Mono-Kover, a slit, one-piece, sectional type molded mineral wool pipe insulation that snaps into place, are covered in 4 p. bulletin.
200E Baldwin-Hill Co.

Linings, Tank.....Acid-proof rubber linings are made from thick, multiple calendered sheets of natural or synthetic rubber for maximum durability. Securely bonded to metal. Cat. 7115.
154 *Raybestos-Manhattan Inc.

Titanium.....Titanium, now readily available for non-defense applications, is actually the least expensive metal you can use under many corrosive influences. Light and strong. Ask for Booklet.
22-3 *E. I. du Pont de Nemours.

Electrical & Mechanical

Connectors, Binding Posts.....4 p. Bulletin BP656 describe company's 5-way binding posts said to combine utility and beauty for easier circuit and polarity identification, better looking panels.
200F Superior Electric Co.

Detector, Ground.....Bulletin C57 describes PRD-C5700 Ground Detector, an electrical device with visual and audible alarms that indicate ground faults.
200G Principle Research & Development.

Drives.....All steel shaft mounted drive can be used in a screw conveyor, bucket elevator, gravel classifier, belt conveyor, apron feeder or line shafting. Request helpful Bulletin 7100 now.
77 *Falk Corp.

Electrical Tapes, Thermosetting.....Advantages of new thermosetting tapes are set forth in new 4 p. booklet. Tables of electrical and physical properties are listed for 15 tapes. Ask for booklet.
200H Minnesota Mining & Mfg. Co.

Entrainment Separator.....Graphite separator, non-clogging, corrosion-resistant illustrated in catalog section S-6900. Tables list separation efficiencies, working pressures and unit dimensions.
200I National Carbon Co.

Hose Clamps.....Complete line of hose clamps for wide variety of industrial uses illustrated in new catalog. Tables of clamp sizes, design features and materials specifications included.
200J Ideal Corp.

Hose Reels.....New 16 p. catalog describes diversified line of hose reels for industrial use. Included are hose reels for handling liquids and gases, cable and rope storage. Send for your copy.
200K Clifford B. Hanny & Son.

Ladder Stands.....8 p. catalog gives specs for Alco-Lite mobile all-steel Safety Ladder-Stands. Height, platform size, width and depth, overall height for 30 models from 1 to 8 steps.
200L Aluminum Ladder Co.

Lighting Equipment.....Bulletin 2697 includes line of floodlights, searchlights, aviation lighting, industrial lighting two new items mercury vapor floodlights and Vapor Master lighting fixtures.
200M Crouse-Hinds Co.

Motor Windings, Silicone.....The value of rewinding motors with silicone insulation is appraised in dollars-and-cents terms in new brochure. Features several complete case histories and applications.
200N Dow Corning Corp.

Nuts, Large.....New 4 p. catalog is complete buying manual for users of large fasteners. Complete specifications, dimensions and prices given for nut sizes ranging from 1½" up through 4".
200O Acimet Mfg. Co.

Packing, Sheet.....8 p. illustrated bulletin gives specs, engineering, application, test data on 19 varieties of industrial sheet packing including those made of asbestos, rubber, silicone, Teflon.
200P Crane Packing Co.

Rheostat Elements.....Wide range of carbon discs, plates and pile assemblies for all types of carbon pile rheostats are discussed and illustrated in 5 p. "Carboneering" bulletin. No. 6 AE.
200Q Speer Carbon Co.

Rings, Metal Raschig and Lessig..... What you expect from metal Raschig and Lessig rings is described in the Metallo product line catalog. Also contains information on valve disks and gaskets.
200R Metallo Gasket Co.

Seals, Mechanical.....'Mechanical Seals for Boiler Feed Pump and Other Hot Water Services," 4 p., contains a schematic boiler feed pump sealing arrangement, photographs of installations.
200S Crane Packing Co.

Seals, O-Ring.....New handbook covers design and application of synthetic rubber o-ring seals. Consists of 160 pages of data on gland design, static and dynamic seals, installation, o-ring sizes, etc.
200T Parker Appliance Co.

Shaft, Flexible Link.....Three new features—equal torque in either direction, equal flexibility in all sizes and unlimited length—now available in a flexible shaft. Ask for technical data.
200U Clark Flexible Link Shaft.

Slings, Woven Wire.....1 p. flyer describes use in materials handling of all-metal woven wire constructed Gripper Slings. Said to be gentle as canvas, safer than wire rope. Send for your copy.
200V Cambridge Wire Cloth Co.

Starters.....Company offers the A-B Handy Catalog, with full information on their line of starters, including Type 1 general purpose enclosure, Type 4 watertight enclosure and other types.
159 *Allen-Bradley Co.

Steam Turbine-Generators..... 54 p. bulletin contains information and data on condensing turbines; non-condensing turbines; single, double, triple automatic extraction turbines; admission units.
200W General Electric Co.

Tape, Corrosion-Resistant.....Brochure describes tar-impregnated glass tape for preventing corrosion in flashings, process piping etc. Booklet gives applications, specifications and coverage chart.
200X Twinsburg-Miller Corp.

Tower Internals.....Corrosion resistant carbon, graphite and "Karbate" impervious graphite packing support structures, bubble cap trays and sieve trays are used in towers. Cat. Sect. S-7340.
65 *National Carbon Co.

Transformers, Silicone Insulated..... Company offers a list of equipment manufacturers who supply Dow Corning silicone-insulated dry-type transformers. Easy, low-cost installation, reliability.
46 *Dow Corning Corp.

Turbine, Combustion Gas.....GED-3546 describes versatility in application of combustion gas turbine in various industrial fields. Covers prime movers ranging from 6,700-30,400 hp., 4,750-21,800 kw.
201A General Electric Co.

Variators, Speed.....16 p. bulletin describes line of packaged direct-current adjustable speed drives available from 3 through 150 hp., 220, 440, 550 v., 3-phase a.c. cycle. Bulletin GEA-6643.
201B General Electric Co.

Wheels.....A complete new catalog covering all data for entire line of industrial wheels is now available. Features "Loadmaster" wheel with Neoprene tires together with standard line.
201C R & K Industrial Products Co.

Handling & Packaging

Belts, Chain.....Complete line of steel chains, sprockets, buckets, gravity take-ups, bearings and drag chains is illustrated and described in 24 p. Bulletin 5766. Includes selection tables.
201D Chain Belt Co.

Fork Trucks, Electric.....Comparison chart enables users of electric fork trucks simultaneously to survey operating design and maintenance characteristics of three different trucks.
201E Lewis-Shepard Products.

Hoist Trolleys.....New "Hoistractor" is an air-powered hoist trolley, connected to any beam hoist by a draw bar, which rides the same beam as the hoist. Simplifies moving heavy loads. Bul. 87-1.
87 *Gardner-Denver Co.

Racks, Storage.....Thirty photographs of a full line of industrial storage racks appear in new 4 p. bulletin. Each is accompanied by a paragraph of description and specifications.
201F M-H Standard Corp.

Tanks, Aluminum.....16 p. technical guide covers design, fabrication and applications of aluminum tanks and vessels. Lists more than 100 types of chemicals for which Al applications are advantageous.
201G Reynolds Metals Co.

Heating & Cooling

Coils, Heating.....Platecoil units help you save on engineering, fabricating, installation, operation and maintenance costs. Double or single embossed, banked or rolled. Manual P61.
89 *Tranter Mfg. Inc.

Exchangers, Heat.....8 p. bulletin describes Impervite impervious graphite tube and shell heat exchangers. Covers corrosion, thermal characteristics, life expectancy, design details.
201H Falls Industries.

Fabricators, Heat Exchangers..... With standardized heat exchangers, you can save work, save engineering costs, save delivery time and save on repairs. Bulletin 250 is available on request.
102 *Whitlock Mfg. Co.

Heat Exchangers.....Bulletin 707 describes Vilter condensers, brine coolers and heat exchangers, while Bulletin 427 discusses Vilter industrial heat exchangers. Request your copies.
183 *Vilter Mfg. Co.

Heat Transfer Equipment.....Company makes steam jet ejectors, steam vacuum refrigeration plants, barometric condensers, surface condensers, heat exchangers, evaporators and coolers. Bul. 62S.
201I Graham Mfg. Co.

Heaters.....Remote evaporation and drying by infrared radiation is now possible with a new water heater for laboratory and semi-industrial use. Radiator is placed above a flat crucible. TD 1318.
33-4q *U. S. Industrial Chem. Co.

Heaters.....Products Catalog No. 956 contains the full story on company's unit heaters, blast heaters and radiation for chemical plant use. Cast iron steam heat transfer surface is described.
206 *D. J. Murray Mfg. Co.

Heaters, Electrical.....4 p. bulletin describes electrical armored heaters operating at temperatures of 840 F. and 1,470 F. Gives data on uses with metal vessels and pipes, construction, loading.
201J Arthur S. LaPine & Co.

Heaters, Fuel Oil.....20 p. booklet, "M & L Fuel Oil Heaters," covers applications of fuel oil heaters to problems of industrial buildings. Contains installation diagrams, table of multipliers.
201K Manning & Lewis Engrg. Co.

Heater, Oil ....Bros oil heaters feature weatherproofed electrical system and centralized controls on weatherproof control box. Applicable where temperatures to 500 F. and low pressures are required.
201L Bros Inc.

Nozzles, Gas Burner.....Data sheet No. GB 804LE describes straight and elbow types of flanged gas burner nozzles. Pictures, sketches and table of capacities help you select and use them.
201M Hauck Mfg. Co.

Traps, Steam.....44-page Armstrong Steam Trap Book gives you specific data on the selection and sizing of traps, how to install them for best results and how to maintain them most economically.
39 *Armstrong Machine Works.

Instruments & Controls

Air Monitor.....Form 3004-7 tells of mobile monitoring device for detection of airborne radioactive contamination. Valuable personnel protection device where danger of radiation exists.
201N Victoreen Instrument Co.

Analyzer, Hydrogen.....Basis for improved techniques for gravimetric determination of hydrogen in titanium, zirconium and metal hydrides is Leco Model 534-100 hydrogen analyzer.
201O Laboratory Equipment Corp.

Controls, Pressure Vacuum.....One-page Bulletins 5-1, 5-2, 5-3 and 5-4 describe some of company's sensitive pressure-vacuum controls. Contain tables of specifications, photographs and drawings.
201P United Electric Controls Co.

Controllers.....M/58 Consotrol controller with floating disc and matched bellows is sensitive, versatile, simple and easy to adjust. Request your copy of information Bulletin 13-19.
20-1 *Foxboro Co.

Controller, Pneumatic.....Type VC pneumatic controller features proportional band adjustment from 2 to 500% and less than 0.05% dead band. Also remote pneumatic or local spring set point adjustment.
201Q Republic Flow Meters Co.

Detectors, Level.....The Capaci-Trol is an electronic-electric level alarm and control unit for detection of level position in vessels. Compact construction, no moving parts. Bul. F-2408.
31 *Fisher Governor Co.

Gage Cleaner.....Data sheet 301 describes and illustrates method of operation of gage glass cleaning tool which used brushes to clean inside of liquid level gage glass. Diagrammed instructions.
201R Jerguson Gage Co.

Gage, Pressure.....Newsletter directed mainly to those interested in aerosol pacakaging and marketing is "Pressure Gauge." Includes news, comment on developments in field, technical bulletin.
201S Aerosol Techniques.

Gas Blender.....For quality control of continuously flowing special atmospheres and gas mixtures, for oxygen or hydrogen burnout, or for uniform quality of cylinder mixes, request bulletin GB 8-57-2M.
202A Gow-Mac Instrument Co.

Instruments, Kiln.....Complete information about oxygen analyzers and recorders for rotary kilns is found in process data sheet 705 (1). Photos and diagrams illustrate all details of system and installation.
202B Leeds & Northrup Co.

Instruments, Precision.....Bulletin M-1 pictures and briefly describes line of precision instruments for measuring, indicating, recording and controling the rate of flow of all types of fluids.
202C Schutte & Koerting Co.

A or a?

It's important, when you circle code numbers on the Reader Service postcard, to watch the letters as they appear with the code numbers.

Capital letters: A, B, C, etc. are used for editorial items.

The small letters: a, b, c, etc. are used for different items within an advertisement.

To make sure you get what you want, circle numbers with capital or small letters as they appear on items or in your Product Index (p. 195).

* From advertisement this issue

Irradiator.....Hotrodder is self-contained research tool using radioactive cobalt. Used to study radiation applications in food, pharmaceutical, plastics and petroleum industries.
202D Budd Co.

Meters, pH.....Five-bulletin package includes information on pocket, laboratory and plant model pH meters. Revised section features pH electrodes in simplified chart form; indexed.
202E Beckman Instruments.

Optical Tester.....For economical inspection methods in research and quality control, Projectina optical precision unit combines into one portable housing microscope-projector-comparator-camera.
202F Alfred Hofman & Co.

Potentiometer.....6 p. bulletin, T-57, features Thermotest portable potentiometer for meausring temperatures and voltages. Measures temperatures from −200 F. to +600 F., voltages to 20.1 millivolts.
202G Technique Associates.

Potentiometers.....New line of small-size and self-balancing electronic potentiometers and bridges; both recording and indicating versions. Details available in 4-page bulletin P1271.
202H Bristol Co.

Recorders.....4 p. leaflet pictures and describes two direct recording oscillographs, Nos. 601 and 602. Outlines features such as record speeds, timing system, multiplexing, external timing.
202I Midwestern Instruments.

Scratch Tester.....Rondeau Scratch hardness and adhesion tester provides means of accurately studying the scratch-hardness vs. adhesion properties of organic protective coating systems.
202J Gardner Laboratory.

Stethoscope, Industrial.....Airsonic, Belgian-made industrial stethoscope, is non-electric, has no diaphragm, has no fixed frequency of its own, picks up sounds of all frequencies.
202K M. Paquet & Co.

Tape Recorder, Airborne.....Engineered for precise data recording in aircraft, marine, vehicular and laboratory environments. Details set forth in new bulletin 1578. Request your copy.
202L Consolidated Electrodynamics.

Thermometer, Metal Probe.....Folder gives details on two fast-reading metal-probe thermometers — integral-probe and remote-probe types. Data on accuracy, response and range of scales is included.
202M Royco Instruments.

Transmitter, Liquid Level.....Model "P" pneumatic pressure and liquid level transmitter measures pressures as high as 250 psi. or ranges from as low as 0 to 100 in. of water. Bulletin P-2520-3.
202N Conoflow Corp.

Pipe, Fittings, Valves

Couplings, Shaft.....Full-floating shaft couplings described in Bulletin 98 are used to connect shafts that are spaced far apart. Recommended for cooling tower drives; fan, pump and compressor drives.
202O Thomas Flexible Coupling Co.

Hose, Flexible Metal.....American Flexible Metal Hose and Tubing Catalog, 60 pages, puts all the technical and general information you are looking for at your finger tips. Catalog G-560.
189 *American Brass Co.

Pipe, Channel.....4 p. circular illustrates and describes installation features and specs of Chemi-Drain Channel Pipe. Vitrified clay product used to handle corrosive fluid industrial wastes.
202P Logan Clay Products Co.

Pipe, PVC.....30 p. catalogue provides specific information on general characteristics of PVC pipe, its properties, applications and installation data. Also corrosion resistance ratings.
202Q A. M. Byers Co.

Pipe, PVC.....Corrosion-resistant polyvinyl chloride pipe prevents contamination, environmental effects and rodent attack, and it is easy to install. Bulletin includes detailed charts.
202R A. M. Byers Co.

Pipe, Welded Steel.....8 p. publication describes welded steel pipe for industrial use. Covers applications, advantages, data on pressure design and dimensions. Bul. SWP-14457.
202S Armco Drainage & Metal Products.

Tubing, Steel.....Company supplies corrosion and heat-resistant tubing for your pressure, mechanical, structural and sanitary requirements in a variety of types and shapes. Bulletin T.D. 120.
170 *Carpenter Steel Co.

Tubing, Steel.....4 p. bulletin contains information on stainless steel and special purpose alloy tubing and pipe available for use in nuclear energy applications. Lists more than 34 analyses.
202T Carpenter Steel Co.

Valve Operators.....LimiTorque valve operators can be furnished as a packaged unit including electric controls and push button. Can be field-mounted on your present valves. Catalog L-550.
44 *Phila. Gear Works.

Valves, Control.....Catalog 307 introduces Schade Series 30 control valves. Designed for control of all types of fluids and combine balance and accuracy of control with single-seated tight closing.
202U Schade Valve Mfg. Co.

Valves, Control.....New 12 p. bulletin pictures sliding sleeve, single plunger, "O"-type, "B"-type and high pressure hydraulic valves. Describes construction and operation of each and its service.
202V C. B. Hunt & Son.

Valves, Corrosion-Resistant.....Folder 205 describes Jenkins Type 2 cast iron gate valves with 316 stainless steel trim. Materials resist acids, sea water, alkaline solutions, etc. Send for your copy.
202W Jenkins Bros.

Valves, Needle.....4 p. brochure outlines features of N-20 and N-28 globe type needle valves. Also describes uses to which valves may be put, supplies technical data in chart form.
202X Kerotest Mfg. Co.

Valves, Solenoid.....Company offers a complete selection of corrosion resistant 2 and 3 way solenoid valves in several materials. Ask for Corrosion Resistant Valve Bulletin with rating chart.
29 *Automatic Switch Co.

Valves, Steam Jacketed.....New Bulletin 100 describes line of Gato Steam Jacketed Valves used in chemical industry. Shows details and operation of non-lubricated split plug valve design.
202Y Gato Valve Co.

Valves, Temperature Control.....6 p. Bulletin 655 shows how to select, size and order temperature control valves. Tells how to select proper body material, valve trim, thermal systems.
202Z OPW Corp.

Valve, Vacuum.....Choice of flange dimensions and minimum space between flange faces is featured in 6-in. VG-106T high vacuum valve. Design permits simple, uncomplicated piping.
202AA Vacuum Research Co.

Process Equipment

Blenders.....Now you can intimately blend any liquid, regardless of viscosity, into dry solids in one fast step—up to 40% liquid volume by weight. Bul. 15A on lab units, Bul. 7-15-A for production.
103 *Patterson-Kelley Co.

Blending System.....Airmerge System, means of blending pulverized materials in a silo through quadrant aeration, is described in B-1 bulletin. Typical installation and blending principles are covered.
203A Fuller Co.

Crystallizers.....Manufacturer's bulletin presents full line of Krystal crystallizers — evaporator, vacuum, cooling and batch type. Applications, operating features and economies itemized in detail.
203B Struthers Wells Corp.

De-Airing Machines.....Vac-Aire deairing machines extrude any material that is plastic enough to flow, such as grease sticks, soaps and detergents, carbide, clay, etc. Bulletin H1.
177a *International Eng. Inc.

Dissolvers.....Highest quality metallic dispersions can now be easily controlled and produced in big volume. Bulletin 21-1957, "Metallic Dispersions with the Cowles Dissolver", is offered.
43 *Morehouse-Cowles Inc.

Dryers.....Kemp gas dryers protect air-operated instruments from corrosion and freezing or jamming, dry inert gases for purging and blanking, dry atmosphere and process gases. Bulletin D-100.
50 *C. M. Kemp Mfg. Co.

Dryers.....Company offers free booklet entitled, "Because Moisture Isn't Pink", with information on the many applications of Lectrodryers in industry today. It is available to you on request.
169 *Pittsburgh Lectrodryer Div.

Dust Collectors.....Hi-Spin, high efficiency dust and products collectors pay for themselves in terms of reduced waste, lower power requirements of fan. Ask for Bulletin 150-A.
203 Sprout, Waldron & Co.

Feeder, Chemical.....A-690 feeder features self-cleaning feed screw which discharges chemical alternately from each end of feed tube. While one end of screw discharges material, other is cleaned.
203D Wallace & Tiernan.

Feeders, Rotary Airlock.....There is a Prater airlock for your needs, from low pressure dust control to high pressure pneumatic conveying. Booklet P-55, "How to Select a Rotary Airlock Feeder".
B188 *Prater Pulverizer Co.

Feeder, Slurry.....Self-contained slurry feeder for handling concentrated slurries can handle 20%-by-weight slurry concentration of diatomaceous earth on a continuous basis. Model A-710.
203E Wallace & Tiernan.

Filter Fabric, Orlon.....Filter fabric for wet or dry filtration is described in one-page flyer. Sample of the Orlon cloth is included along with laboratory test data.
203F Filtration Engineers.

Filters.....Condensed catalog is a quick reference to the complete line of Fulflo and CFC filtration equipment providing continuous micro-clarity, lower maintenance costs. All types of fluids.
49 *Commercial Filters Corp.

Filter.....16 p. booklet summarizes characteristics, applications of MF Millipore filter membranes for analysis of liquid and gas dispersed particles; introduces high-strength Microweb membranes.
203G Millipore Filter Corp.

Filters.....8 p. brochure describes metal-edge filters with flow from 1 to 1,000 gpm. which can withstand temperature extremes from —260 F. to 1,200 F. Includes construction, maintenance details.
203H Purolator Products.

Filter, Air.....Filter screens out particles as fine as 0.1 micron and will withstand temperatures up to 2300 F. Bulletin offers complete technical information on Airpure line of filters.
203I Flanders Filters.

Lubricators.....Manzel is the accepted source for lubricator requirements up to 30,000 psi. Outstanding dependability in regular line of forced feed lubricators. Ask for complete catalog.
168 *Manzel Co.

Mill, Compacting.....Compacting mill provides low-cost, mechanical means for converting or upgrading particle size, and for controlling product density and product solubility factors. Bulletin 07B8836.
203J Allis-Chalmers Mfg. Co.

Mixers, Laboratory.....Complete design and construction details as well as dimensions, weight, operating speeds are given for Sprout-Waldron Laboratory Unit in Bulletin 188.
203K Sprout, Waldron & Co.

Processing Equipment.....Company offers an informative treatise on equipment and systems for processing dry and semi-dry materials. Conveying, storage, reduction, mixing, shipping. Bulletin 95.
47 *Sprout-Waldron Co.

Reactors, Research.....Research reactors now operating or being built in the U.S. are reviewed by a new government booklet which includes data and illustrations on over 30 reactors. TD 1311.
33-4j *U. S. Industrial Chem. Co.

Separators.....4 p. bulletin covers operating principles, design and standard mesh styles of Yorkmesh Demisters (mist eliminators and entrainment separators). Data on engineering, installation.
203L Otto H. York Co.

Wire Rope.....New Bulletin DH-128-B covers complete line of Tru-Lay preformed wire rope, wire rope accessories and Dualoc Boom cable assemblies. Contains data on construction, applications, etc.
203M American Chain & Cable Co.

Pumps, Blowers, Compressors

Compressors.....The rotary operation of company's compressors gives a remarkably stabilizing effect, without the shimmy and shock of reciprocating compressors. Bulletins 16B8244 and 16B8126.
97 *Allis-Chalmers Mfg. Co.

Compressors, V-Angle.....Bulletin No. 84 describes Type GMXF compressors, parallel turbocharging of engine-driven compressors for service from 330 to 825 brake hp. on field gathering repressuring.
203N Cooper-Bessemer Corp.

Fans, Centrifugal.....Illustrated bulletin showing details of Ilg BC Airfoil fans for all types of ventilating and air conditioning installations. Performance graphs, capacity tables, drawings.
2030 Ilg Electric Ventilating Co.

Pumps.....Slurry pumps handle abrasive, corrosive pulp with dependable efficiency and economy. All wearing parts are moulded of Maximix rubber or neoprene, which outlast metal. Brochure 557.
63 *Allen-Sherman-Hoff Pump.

Pumps.....Nagle centrifugal pumps are designed and constructed exclusively for the dirty, gritty, abusive jobs—for pumping slurries, slimes, tailings, corrosive or hot liquids. Catalog 5206.
T188 *Nagle Pumps Inc.

Pumps, Centrifugal.....Company offers a catalog containing engineering data, performance charts, diagrams and helpful general information on line of centrifugal pumps. Request Bulletin 110F.
69 *Eastern Industries Inc.

Pumps, Rotary.....Heavy-duty GAR pumps feature simple construction—herringbone gears and roller bearings allow long, trouble-free service. Capacities to 25 gpm.; pressures to 500 psi. Bulletin 2064-B1.
203P Worthington Corp.

Services, Processes, Misc.

Carbon Dioxide Producers.....Bulletin 7W88, 4 p., describes and illustrates company's new series 0 and 00 Carball units which provide a source of CO_2 for small treatment plants. Flow diagram shows typical installation.
203Q Walker Proc. Equip. Co.

Clothing, Protective.....Controlled PVC-impregnated foul weather clothing is tough and long-wearing; designed to give freedom of movement and excellent ventilation. It resists water, sunlight, chemicals.
204A Jomac Inc.

Color Standards.....Slide-rule type chart gives instant comparison between five commonly used scales, including Gardner 1933, National Petroleum Association and American Society for Testing Materials.
204B Armour & Co.

Construction, Corrosion-Proof.....Company provides an integrated construction service for plantwide corrosion protection, including sales and engineering service. Bulletin C-1.
204C Atlas Mineral Products.

Drainage Systems.....Molded polyethylene waste and drainage systems are now on the market. Traps, pipe, joints, fittings will withstand intermittent flushings with boiling water. TD 1320.
33-4s *U. S. Industrial Chem. Co.

Drainage Systems, Lead.....Third of a series of Lead Building Construction Bulletins covers specifications for lead chemical laboratory drainage systems. Suggested installation methods are included.
204D Lead Industries Assn.

Fire Protection.....Booklet explains advantages of sprinkler fire protection systems. Shows how savings on insurance premiums can pay for the cost of the system in a few years.
204E Automatic Sprinkler Corp.

Fire Protection Systems.....Dualguard fire protection combines a regular sprinkler system with a sensitive heat detecting system, gives fire warning before the water is released. Bulletin.
204F Rockwood Sprinkler Co.

Hydraulic Fluids.....Bulletin No. 1300SA describes characteristics of petroleum base and fire-resistant hydraulic fluids. Tells how to select fluids for given jobs, how to care for them.
204G Vickers Inc.

Laboratory Equipment.....Brochure describes company's new Ultraburet, model 200. Instrument is said to offer a unique combination of accuracy at low ultra micro readings, high capacity, speed.
204H Scientific Industries, Inc.

LITERATURE . . .

Laboratory Supplies.....1 p. flyer describes company's Diamonite Mortars and pestles made of a unique synthetic sapphire substance. Discusses properties such as chemical inertness, abrasion resistance.
204I Diamonite Mfg. Co.

Microradiography.....Folder on projection microradiography explains how apparatus extends usefulness of light and electron microscope investigations. Photos of equipment, micrographs included.
204J Philips Electronics.

Microscopy.....Analytical microscopy relative to food, drugs, spices, water is discussed in a new 215-page book. Describes preparation of materials for examination and problem solutions. TD 1316.
33-40 *U. S. Industrial Chem. Co.

Nuclear Plants.....8 p. booklet entitled "Instrumentation and Control of Nuclear Plants" covers, in detail, reactor power control, reactor nuclear instrumentation and coolant instrumentation.
204K Westinghouse Electric Corp.

Oxidation, Catalytic.....Applications of catalytic oxidation to air-pollution control problems in carbon black, insulation, oil refining, chemical processing industries are reviewed in technical reprint.
204L Oxy-Catalyst.

Pens, Marking.....Marking pen consisting of a heavy-wall polyethylene squeeze tube with felt writing point writes on porous and nonporous surfaces. Low-cost, comes in seven colors. TD 1312.
33-4k *U. S. Industrial Chem. Co.

Plant History.....Short review of Gallery Chemical Co.'s growth in people, plants, products and processes is presented in 12 p. booklet. Covers development of boron cpds. Request your copy.
204M Gallery Chemical Co.

Pulverizing.....3 p. leaflet describes company's service in the field of pulverizing all kinds of heat-sensitive materials through the use of liquid nitrogen. Some materials pulverized: Teflon, nylons, acrylics.
204N Liquid Nitrogen Proc. Co.

Refiner, Pilot Plant.....24-in. refiner operates equally well with dry feed, using separately driven screw feeder, or with "fluid" feed. precision built for securing accurate results. Bul. 184.
2040 Sprout, Waldron & Co.

Research....."From Raw Materials to Complete Systems," 8 p., highlights company's activities in materials research, component development, data instrumentation, ultrasonic and acoustic research.
204P Gulton Industries.

Teflon Molding.....4-page brochure covers patented process for custom molding parts of Teflon in thin sections and shapes. Includes properties of Teflon and illustrations of many molded parts.
204Q Sparta Mfg. Co.

Television, Industrial.....Investigate the versatility, simple operation and low cost of industrial TV systems by sending for the free illustrated brochure entitled "How Many Jobs" now.
175 *General Precision Lab.

* From advertisement this issue

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READER SERVICE . . .

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Still available: These highly popular and valuable editorial reprints from past issues of Chemical Engineering. They'll help keep you on top of your profession.

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76 Liquid Proportioning—Equipment, methods and uses (50¢).
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CLASSIFIED . . .

EMPLOYMENT OPPORTUNITIES

CE's nation-wide coverage brings you each month tips and information on current opportunities in job functions throughout the chemical process industries.

▶ **Coverage** — National, Executive, management, engineering, technical, sales, office, skilled. Positions vacant, positions wanted, civil service, selling opportunities, employment agencies and services, labor bureaus.

▶ **Displayed Rates**—$46 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Subject to the usual agency commission.

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▶ **Closing Date** — February 24th issue closes February 3rd. Send new ads to Chemical Engineering, P. O. Box 12, New York 36, N. Y.

TECHNICAL NEWS EDITOR

Opening on Chemical Engineering's editorial staff for a young engineer to develop and write technical news on chemical processes, methods, plants, products and equipment. Unusual opportunity to broaden contacts, education and experience. Requirements: Degree in chemical engineering; up to three years industry experience; ability to evaluate technical information; able to write clearly and accurately; ability to work well with people, initiative and imagination. New York City location. Send resume and salary requirements to:

John R. Callaham, *Editor-in-Chief*
Chemical Engineering
330 West 42nd Street
New York 36, N. Y.

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POSITION VACANT

Plant Superintendent. Large liquid oxygen manufacturer desirous of hiring graduate engineer with experience in installing and operating tonnage oxygen plants and customer liquid installations. Must have management ability and experience. Position open on West Coast. P-7005, Chemical Engineering.

POSITION WANTED

Project Engineer, Chemical, desires position in Philadelphia area. Experience includes sales engineering, plant equipment and piping design, plant management in heavy chemicals, complete supervision of erection Chlorine-Caustic Soda and Hydrogen Oxygen Cell Plants, writing operation and maintenance manuals and specifications. Some process control engineering. Penn State Univ. B.S. degree. Married—five children. Salary open to offer. Resume on request. PW-7039, Chemical Engineering.

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Minimum 15 years diversified experience. Must be experienced in plant design, construction and operation and qualified to act as consultant to foreign government on development of basic chemical industry. Extensive experience in fertilizers important with background in general commercial chemicals desirable.

Possibility of 24 to 30 months foreign service. Good living conditions; substantial salary; quarters and travel allowance. Age 40 to 65.

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Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising.

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P-6951, Chemical Engineering
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Opportunity for career employment in staff department of multi-plant fabricator of durable steel products. Employment in Kansas City, Missouri.

Advancement by merit; complete benefit program; attractive compensation plan. Company-paid retirement.

We visualize successful applicant as having completed work for chemical engineering or mechanical engineering degree, with 3 to 5 years practical experience in problems connected with metal painting and coating. This is a top opportunity for a capable, qualified engineer who wants to use fully his coatings and engineering training and experience.

Send full particulars in confidential letter to *Orval W. Groves, Employment Supervisor* at address shown below.

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MS or PhD Degree

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Send confidential resume including education, experience and current earnings to

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Salary $12,000.00 plus per year. Should have experience in the field of the utilization of aluminum and its alloys, such as aircraft, kitchen utensils, etc. You will probably at present be engaged as a metallurgist or engineer in some aluminum fabricating concern. Company client assumes all employment expense.

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CLASSIFIED . . .

EQUIPMENT SEARCHLIGHT

CE's Searchlight spots the big bargains in used, resale and rental equipment. Check this issue's listings — most complete in the field — for items you need now.

▶ **Coverage**—National (see index of advertisers in this section for your nearest dealer). Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.
▶ **Rates**—$21.75 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.
▶ **Closing date** — February 24th issue closes February 3rd. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

EQUIPMENT SEARCHLIGHT ADVERTISER'S INDEX

FOR SALE

705-24 Roto-Louvre Dryer with aerofin coils, blowers, and controls
502-16 Roto-Louvre Dryer with oil burner, blowers, and controls
6' x 10' Rotary Vac Drum Dryer chrome plated with accessories
4' x 30' Ruggles Coles Model XH2 Rotary Dryer
5' x 30' Buflovak Rotary Vac Dryer
8'6" x 50' x 5/8" Rotary Kiln
15" x 15" Republic S.S. Filter Press 20 chamber Flexmaster
2350 gal. S.S. agitated tank
8' x 8' Rubber lined Steel Tanks
275 Sq. Ft. Condenser S.S. tubes
303 Sq. Ft. Alco Heat Exchanger, Admiralty tubes 350 Psi
1020 Sq. Ft. Heat Exchanger 150 Psi
24" x 20' Swenson Crystallizers (3)
500 gal Glascote Glass Lined Jacketed agitated Reactor
2' x 54' Column 30 Trays 268 Psi
5' x 42' Column 18 Trays
40" SS Bird Suspended Centrifuge perforated basket 30/7½ HP
30" Fletcher S.S. Suspended Centrifuge, perforated basket 10/5 HP XP
C27 Sharples Super-D-Hydrator
Sweetland Filter #10 with 27 Steel bottom drainage leaves
5'3" x 6' Oliver Precoat Filter, Rubber covered, Complete
30" Shriver Filter Press 20 P & F
Mitts & Merrill 30" x 36" Hogs 15CF

HEAT & POWER Co., Inc.

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310 THOMPSON BLDG. TULSA 3, OKLAHOMA Diamond 3-4890

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1—11' dia x 15' Stainless Steel Tank
1—Komarek-Greaves 15 TPH Briquetting Press
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1—8' x 16' Rotary Dryer or Cooler, ½" shell
2—Link-Belt Roto-Louvre Dryers 207-10, 310-16
2—6' x 45' Louisville Flame Dryers
2—6' x 50' Louisville Rot. Steam Dryers
5—4' x 30' Beaird Dryers, Mtrs & drvs
1—Proctor-Schwartz 7 x 60' Apron Dryer
1—42" x 90" Double Drum Dryer, Buflovak
1—Fitzpatrick Model D Comminuting machine
1—Fitzpatrick Model K Comminuting machine
4—Jeffrey Vib. Conveyors, #3 MC-8" 9' long
1—Raymond 3 Roller High Side Cone Separator
1—Williams 4 Roll High Side Whizzer Separ
1—Elmco 8' x 8' Rot. Cont. Filter, Complete
1—Oliver 8' x 10' Cont. Vac. Precoat Filter
1—Sweetland #2 Filter, 9 hot lvs 4" centers
2—Sharples D-2 type 316 S.S. Filters
2—A T & M susp perf basket Centrifuges
1—Tolhurst 32" rubber perf bas Centrifuge. New
1—Day 100 gal double sigma Mixer, Stainless
1—Readco 25 gal dbl arm Sigma jcktd Mixers
1—Baker-Perkins Sigma Mixer, 33 x 37½ x 30"
1—Sturtevant 1½ ton Mixer, 75 cu ft Batch
8—Lightnin Model SEV side enter. Agitators
2—Rietz RD-18 Disintegrators, 75 HP motors
4—Adm. Brass Condensors, 62, 320, 592, 760 sq ft

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MACHINERY AND EQUIPMENT COMPANY GO WEST

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NO BRAGGIN' *BUT*

FMC REBUILT EQUIPMENT EQUALS NEW FACTORY UNITS IN EVERY RESPECT BUT PRICES and IMMEDIATE DELIVERY!

THAT'S WHERE WE'VE GOT 'EM LICKED!

Buflovak Double Drum Dryer; 42" x 100".
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Stokes Jktd. Rotary Vacuum Dryer; 34" x 10'.
Blaw Knox Stainless Resin Autoclave 7'6" x 7'6".
Mojonnier S/S Vacuum Pans; 3' x 10' and 6' x 12'.
Lancaster S/S Lined Rot. Reactor; 50" x 17'4".
8 S/S Heat Exchangers-Condensers up to 1000 sq. ft.
Bird Continuous Conical Bowl Centrifugals; 18" x 28".
Tolhurst 36" S/S Suspended Type Centrifugal S/S Plow.
Sharples C27 Super D Hydrator; Type 317 Stainless.

Tablet Presses by Stokes, Kux, Colton; Single & Rot.
International 8' x 8' Porcelain Lnd. Pebble Mills.
Patterson Buhrstone Lnd. 6' x 8' Pebble Mills.
Baker Perkins S/S 100 Gal. Vac. Dispersion Mixer.
Baker Perkins Size 18; 300 Gal. Dbl. Arm Jketd. Mixers.
J. H. Day No. 10 Cincinnatus S/S 300 Gal. Mixer.

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Autoclave: 50 gal. Struthers-Wells, st. st.
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Centrifuge: Inter. size 3 mod. FS. 2 hp.
Clarifiers: De Laval 34-51, SVK5R, 04-21.
Condensers: stainless steel and copper.
Crystallizers: 500 gal. stainless steel, jack.
Dryers: Devine 2 x 4' vac. drums, st. steel.
Evaporator: Buflovak double effect st. st.
Fillers: for liquid, paste, powder.
Filters: Oliver 2½ x 1', Sparkler, Alsop, Lomax, Industrial.
Filter Presses: Sperry, Shriver 6" to 36".
Kettles: Stainless steel 20 to 500 gal. with and without agitators.
Mills: Pebble, Abbe #5, 36 gal.
Ball: 4 x 5' chrome manganese.
Mikro: Bantam, #1SH, #2TH, 24".
Hammer: Jeffrey 30 x 24" type A.
Colloid: Charlotte Iron, 25 hp.
Mixers: Dbl. and sgl. arm sigma blade. Jacketed horiz. 550 gal. st. steel.
Percolators: Pfaudler 54 x 42" st. st. jack.

Send us your inquiries and list of idle equipment

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IN STOCK

Bird 32" x 50" continuous centrifugals, T316 SS, fume tite

Bird 24" x 24" continuous centrifugals, slotted screen, monel

Bird 24" x 38" continuous centrifugal, steel, 1953

Sharples Super-D-Hydrators C-20 & C-27, T316 SS and monel

Copper bubble or tunnel cap columns: 24", 36", 42", 48" dia., up to 59 plates

Buflovak 42" x 120" double drum dryers (2) with 125# drums, (1) with 160# drums

American 36" x 84" double drum dryer, VACUUM

UNUSED Buflovak 5' x 12' single drum dryer, VACUUM

Andersen SS vacuum shelf dryers, 108 sq. ft., six individual chambers

1070 sq. ft. shell & tube exchangers, T304 SS, ASME 150#

910 sq. ft. shell & tube exchanger, admiralty tubes, ASME 75#

9' x 30' rotary dryer, SS lined

Al. Ch. 6' x 50' Rotary Dryer

Renn. 5'6" x 50' Rotary Dryer

Beaird 4' x 30' rotary dryers

Tylor-Harmor 4' x 30' rotary dryer, double shell

Louisville 6' x 45' rotary steam tube dryer

Nickel-Clad vert. long tube evaporators, 400 & 250 sq. ft.

Buflovak vert. long tube dbl. effect evaporator, 588 sq. ft., S.S.

Niagara #510-28 pressure leaf filter, T316 SS 510 sq. ft.

Sparkler #33-S-28 pressure leaf filters, 151 sq. ft., T304 SS lvs.

Sweetland filters: #12, #7, #5

Eimco 10' D x 12' F rotary vacuum filters, rubber covered

Hardinge 10' x 96" conical mills

Allis-Chalmers compeb mill, 7' x 24', 450 HP

Raymond #15—6-roll low-side mill, 200 HP

UNUSED Patterson 5' x 22' ball tube mill, 200 HP

H. K. Porter pebble mills, 6' x 5', stone lined

Baker-Perkins #15-USE dispersion blade, double arm mixer, SS, 100 gal; 75 HP

Davenport #1A Dewatering Presses

NEW 10,500 gallon horiz. SS tanks

3000 gal. SS tank trailers

Agitator Drives: 11:1 @ 60 HP; 10:1 @ 250 HP

FOR MORE *IN STOCK* VALUES, Send For List #158

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH STREET

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Here Is Your Opportunity To Acquire Boiler Plant At a Very Reasonable Price

2—560 H.P. Erie City Self Contained Water Tube boilers, 160 lbs. with Canton Stokers. Can be moved without dismantling.

3—250 H.P. Titusville Firebox Boilers No. W.P. 250, 125 lbs. pressure, 1944, 2500 sq. ft. Heating Surface.

2—200 H.P. Erie City Economic Boilers No. 152, 125 lbs. pressure, 1944, 2000 sq. ft. heating surface.

1—250 H.P. Erie City Economic Boiler No. 174, 150 lbs. pressure, 1944, 2641 sq. ft. heating surface.

CONDITION EXCELLENT

All the above firebox boilers are equipped with Riley hydraulic stokers, Copes feed water regulators, non return valves, and injectors.

The above is a complete plant. Including complete coal elevator and conveyor system to each boiler, boiler water preheater, water treating system, flow, pressure and draft gauge meters for each unit, all piping valves, etc.

Can be bought as a complete unit or individually. Several 150 H.P. 100 lbs. WP w/stokers also available.

A B C Demolition Corp.

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Blaw Knox 4' x 5' Flaker, type 316 SS with 7½ H.P. motor & drive—LIKE NEW—
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TWIN SHELL DRY BLENDER

- 3 cu. ft. Capacity
- Like new

2—International
BALL MILLS
6' Dia.x8' and 6' Dia.x10'

- Porcelain Lined
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- Excellent Condition

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YOU WILL FIND EXCEPTIONAL FEATURES in all GELB PROCESS EQUIPMENT

11—Pfaudler Glass-lined Series R Jacketed Kettles, 1000 gallons each.
2—Baker Perkins Stainless Steel Double Arm Jacketed Vacuum Mixer, with compression covers 2¼ and 10 gallons working capacity, complete.
2—Struthers Wells Type 316 Stainless Steel Reboilers, 445 sq. ft. and 380 sq. ft.
1—Merco Stainless Steel Centrifuge, Type B9, with 15 HP motor, complete.

CENTRIFUGES:

1—DeLaval Type 316 Stainless Steel Multimatic Centrifuge
1—AT&M 42" Suspended Type Centrifuge, complete with type 347 stainless steel perforate basket, plow and curb, with 40/20 HP motor.
1—Tolhurst 32" Suspended Type Centrifuge with stainless steel Perforate Basket, plow and curb, 25/12½ HP motor.
1—Tolhurst 32" Suspended Type Centrifuge with Imperforate Basket
2—Sharples Type 316 Stainless Steel Centrifuges, Model D-2 (New)

DRYERS:

1—Buflovak Stainless Steel Vacuum Drum Dryer, 12" x 18"
1—Stokes Model 59-DS, Steel Rotary Vacuum Dryer, 5' x 30'
1—Stainless Steel Rotary Dryer, 4' x 20'
1—Stainless Steel Rotary Dryer, 3' x 12' complete
2—Louisville Rotary Dryers, 6' x 45' complete
2—Columbia Engineers Rotary Dryers, 6' 4½" x 45', complete
2—Louisville Rotary Steam Tube Dryers, 6' x 50', complete
1—Bartlett & Snow Rotary Dryer, 4' 6" x 36' 6"
1—Stokes Double Drum Dryer, 5' x 12'

FILTERS:

1—Oliver Horizontal 3' Pilot Plant Filter, New
1—Sparkler Stainless Steel Jacketed Filter, Model 14SS
1—Sweetland #7 Filter with 20 steel leaves
10—Sweetland #12 Filters with 72 Stainless Steel leaves.
1—Feinc Stainless Steel Rotary String Filter, 3' x 3' (New)

AUTOCLAVES, KETTLES AND TANKS:

5—Stainless Steel 2000 gallon Storage Tanks
5—Stainless Steel Jacketed Kettles 250, 350 and 500 gallon capacity
1—1000 gallon Nickel Jacketed Kettle
2—Glascote 150 gallon, glass-lined, jacketed Stills with Condensers and Receivers
1—Stainless Steel Jacketed 400 gallon Kettle with Turbo Agitator and Drive
1—Combustion Engineers Steel Jacketed Autoclave, 1600 gallons, with agitator and drive, 150#, 600# Internal.
1—Autoclave Engineers Type 316 Stainless Steel Autoclave, 5000# pressure, 1 gallon capacity

MIXERS:

1—Baker Perkins #16 TRM 150 gallon Jacketed Double Arm Sigma Blade Vacuum Mixer, 60 HP motor.
2—Baker Perkins Double Arm Sigma Blade Jacketed Mixers, 100 gallons.
1—Gedge Gray Stainless Steel Ribbon Blender, 65 cu. ft.

The Gelb Girl for January 1958, Second choice

1—Banbury Midget Pilot Plant Mixer
3—Robinson Type 316 Stainless Steel Sigma Type Jacketed Heavy Duty Mixers, 400 gallons capacity, 60 HP
1—Leader Stainless Steel Jacketed Horizontal Ribbon Blender, 40 cu. ft.
1—Process Engineers Stainless Steel Jacketed Ribbon Blender, 30 cu. ft.
2—Patterson Kelley Stainless Steel Twin Shell Blenders, 5 cu. ft. ea. Complete.

MISCELLANEOUS:

2—Williams Hammer Mills, Type 316 Stainless Steel, Model AK
1—6" x 12" 3-roll Laboratory Calendar
1—Richmond Engineering, Type 316, Heat Exchanger, 350 sq. ft.
1—CleaverBrooks (Cleaver-Brooks) 80 HP Steam Generator, 125# pressure
4—Type 317 Stainless Steel Heat Exchangers, 892 sq. ft. ea., 200 PSI, ASME Code
6—Karbate 60 sq. ft. Heat Exchangers
2—Combustion Engineers Water Tube Package, Boilers 200 HP 275# pressure
1—Komarek Greaves Briquetting Machine with 50 HP motor
1—Ingersoll Rand Air Compressor with 300 HP motor, 1600 CFM, 100# pressure
1—Williams 4-roll Mill, Complete
1—Raymond 3-roll High Side Mill, complete.

1—Pfaudler Type 316 Stainless Steel Reactor, 1500 gallons, complete with agitator and drive.
1—Williams Stainless Steel Rotary Dryer, 3' x 20'.
1—Stokes Stainless Steel Rotary Vacuum Dryer, 3' x 15'.
2—Patterson Monel Conical Blenders, 4.7 cu. ft. and 12.4 cu. ft

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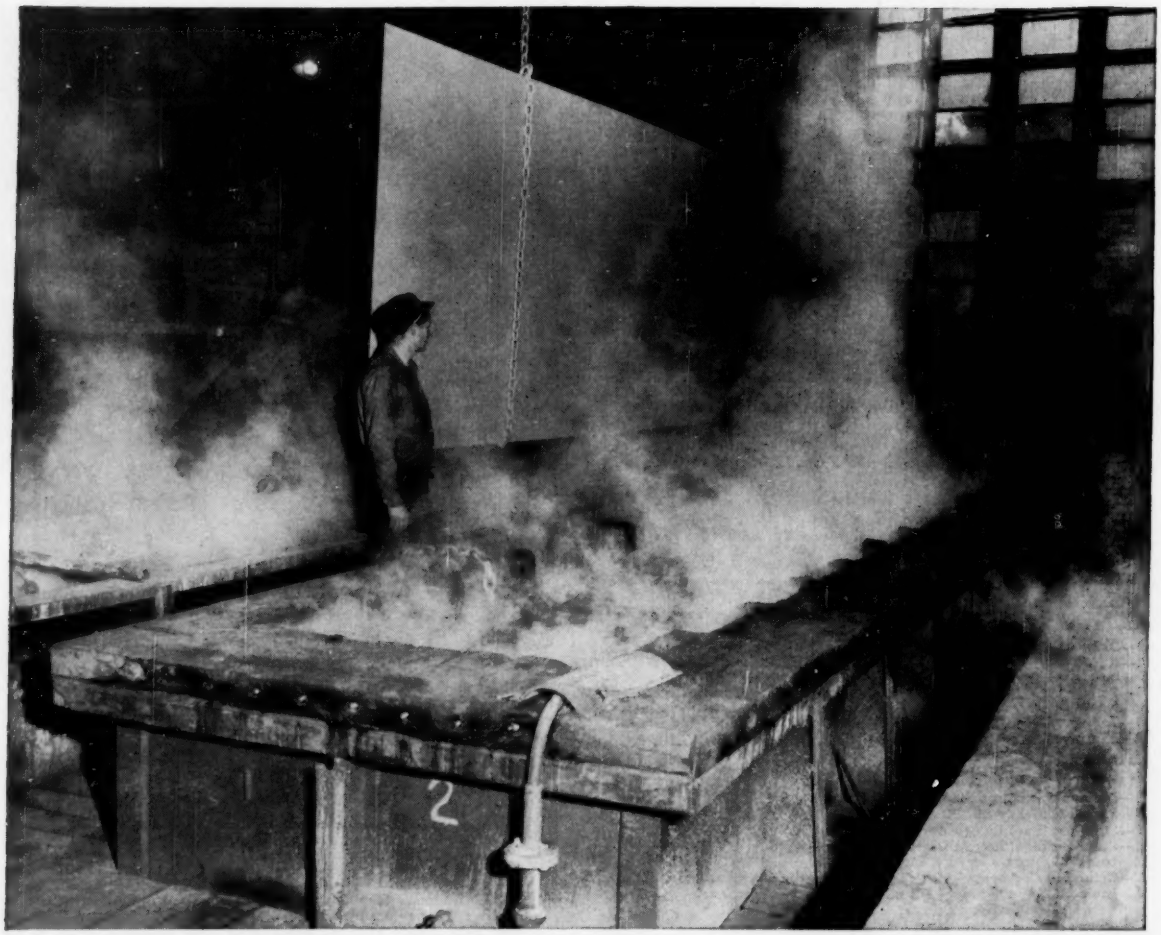
B.F.Goodrich report:



Soaking steel for ships in steaming acid

B. F. Goodrich improvements in rubber brought extra benefits

Problem: That ton of steel plate, soon to be part of a U. S. destroyer, is about to be plunged into a steaming acid bath. This job of cleaning rust and scale off metal used to be plenty dangerous because nothing could hold the corrosive acid. All kinds of tanks were tried—wood, masonry, steel. Yet acid leaked onto the floor constantly—a waste, a hazard to workers.

What was done: A leakproof tank seemed impossible until B.F.Goodrich engineers came up with something entirely new in the way of a protective lining. They developed a combination lining of hard rubber sandwiched between soft rubber, called Triflex, that stands the hot, corrosive acid. The rubber is locked to the steel tank by the exclusive B.F.Goodrich Vulcalock process.

Savings: Acid leaks stopped wherever this B.F.Goodrich lining was used. The waste and hazard of messy, acid-wet floors became a thing of the past. At the shipbuilding company pictured here, B.F.Goodrich rubber-lined tanks have seen service since 1940, are still in use.

Why specify B. F. Goodrich: B. F. Goodrich specializes in rubber equipment to handle acids and other corrosive chemicals. When you buy B.F.Goodrich linings you buy years of engineering background with it—experience that makes sure your lining will be exactly fitted to meet all the special requirements of your work. *B.F.Goodrich Industrial Products Company, Tuscaloosa, Alabama, or Dept. M-243, Akron 18, Ohio.*

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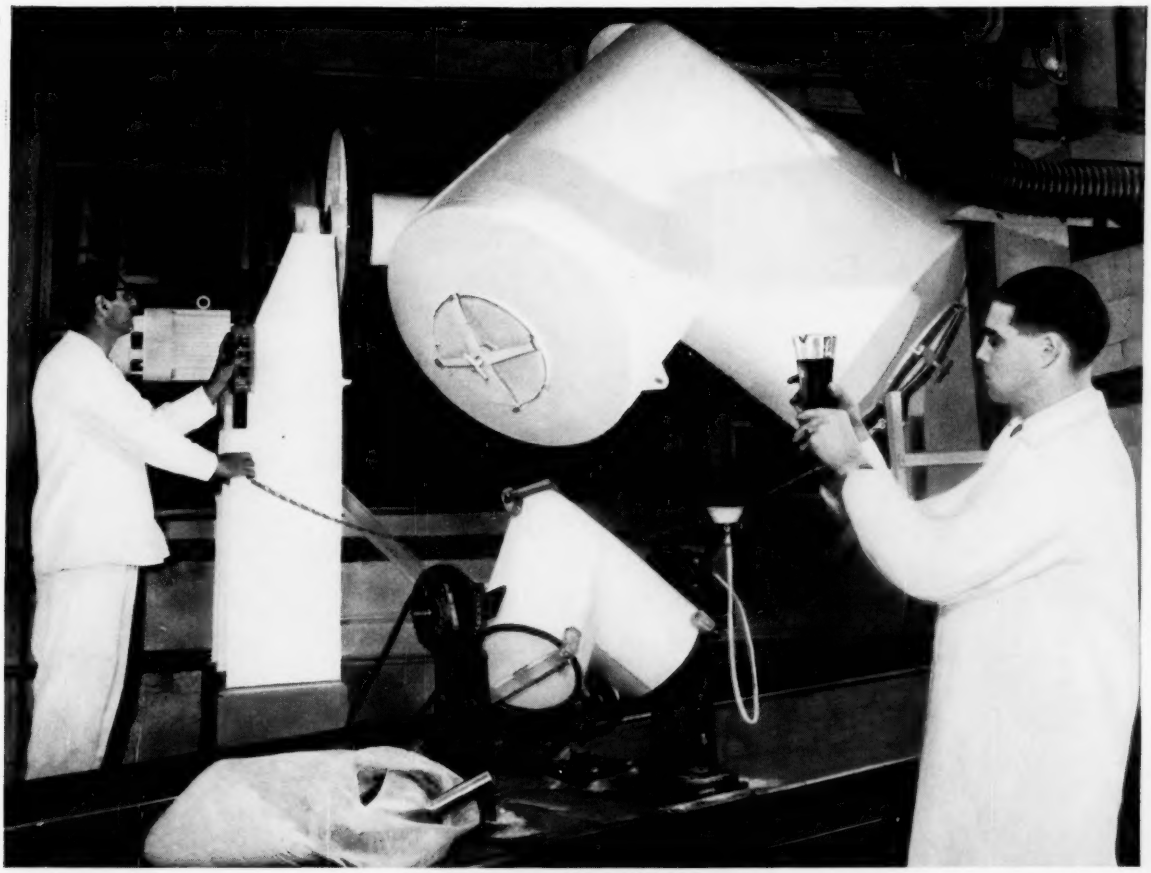
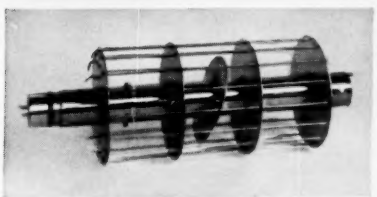
Now! For the first time

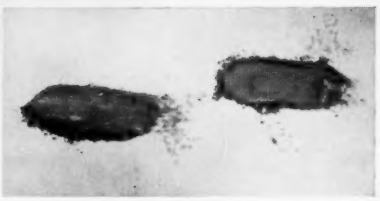
intimately blend any liquid, regardless of viscosity, into dry solids–in one fast step–even up to 40% liquid volume by weight





VERSATILE. This wire cage assembly gives you three blenders in one. With it you can blend liquids into solids, or obtain dry intensive mixing action. Remove it and get gentle blending.

TYPICAL EXAMPLE. Bar breaks down agglomerates in material at left and prevents new agglomeration as liquid is added. Note uniform consistency in finished blend at right.



ABSOLUTE UNIFORMITY. Laboratory smear test reveals streaks where standard blending methods are used (left). With P-K's exclusive design, complete blending is assured (right).

These results can be proved in your own lab with a P-K Laboratory Model Liquid-Solids* Blender. 8 or 16 qt. capacity available from stock for instant delivery.

Scale-ups from lab tests are equalled or bettered in P-K production models with capacities from 1 to 50 cubic feet. This is a completely new concept in liquid-solids blending —exclusive with P-K.

Write now for Bulletins 15A on lab units, 7-15-A on production units of P-K liquid-solids blenders. The Patterson-Kelley Co., Inc. 1502 Hanson Street, East Stroudsburg, Pa.

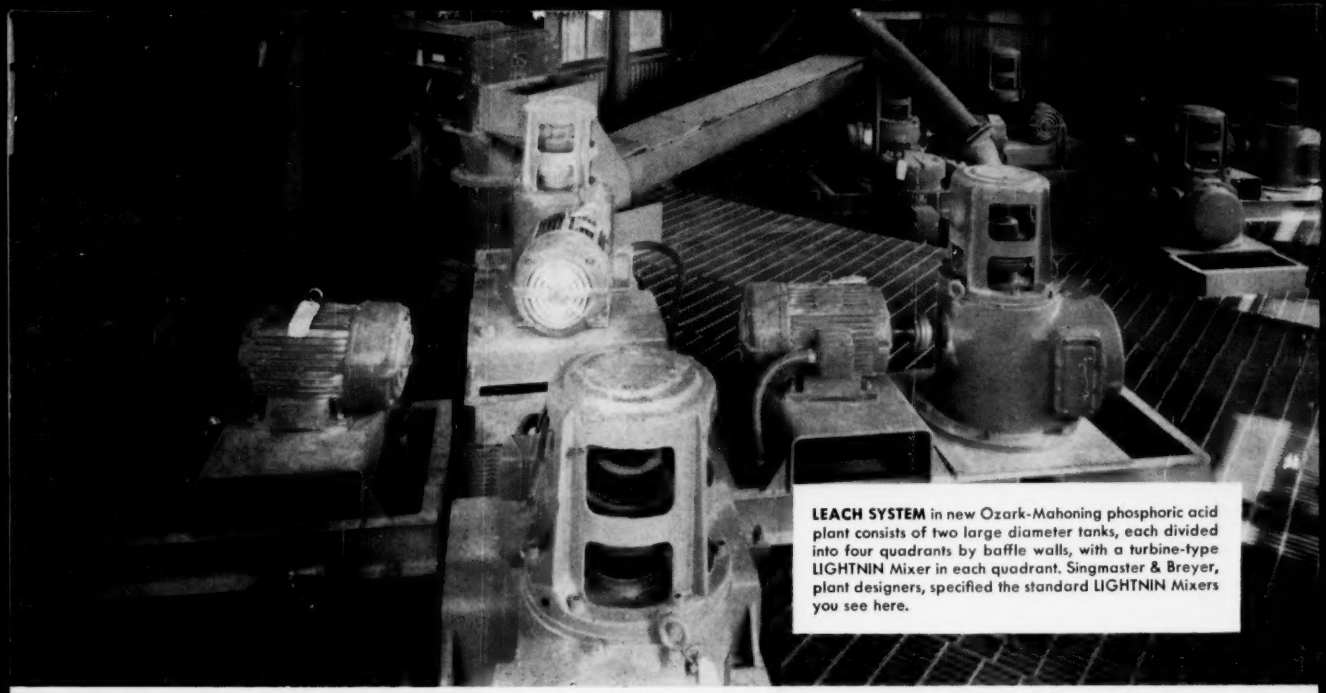
Patterson Kelley

Chemical and Process Division

P-K Twin Shell Blenders* • Heat Exchangers

Packaged Pilot Plants • P-K Lever-Lock Doors*

*Patents pending



LEACH SYSTEM in new Ozark-Mahoning phosphoric acid plant consists of two large diameter tanks, each divided into four quadrants by baffle walls, with a turbine-type LIGHTNIN Mixer in each quadrant. Singmaster & Breyer, plant designers, specified the standard LIGHTNIN Mixers you see here.

New acid process gives **95% yield** *with good mixing in leach tanks*

More often than you might think, *good mixing of fluids* can make the difference between "just average" and superior process results.

That's one reason why LIGHTNIN Mixers were specified for this new wet-process phosphoric acid plant at Ozark-Mahoning Company, Tulsa, Okla. Singmaster & Breyer, New York engineering firm, did the process and equipment design for Ozark-Mahoning Company.

High yield—low cost

Utilizing the Belgian Prayon process, relatively new to this country, the plant consistently yields better than 95% of acid containing 30% P_2O_5. It produces a 32% product from sulfuric acid as weak as 55%.

Leaching temperature is 15-20 degrees cooler than conventional processes—easing the corrosion problem and permitting the use of less costly materials of construction.

The new plant has run without a hitch since the day Ozark-Mahoning operating management pushed the button.

How mixers help

Good mixing does its job in the leach system, where finely ground phosphate rock is slurried with recycled phosphoric acid, then reacted with sulfuric acid to precipitate gypsum.

A LIGHTNIN Mixer in each of eight leach-tank compartments provides the exact balance of fluid flow and turbulence needed for intimate acid contacting and highest extraction values.

The LIGHTNINs also provide complete uniformity and immediate dispersion of reactants, resulting in the growth of large, easily filtered gypsum crystals.

On *your* next project, why take chances on fluid mixing when you can be *sure*? With LIGHTNIN Mixers, you get the security of knowing there's a mixer to match your requirements *exactly*—with replacement parts always quickly available if you ever need them.

Predictable results

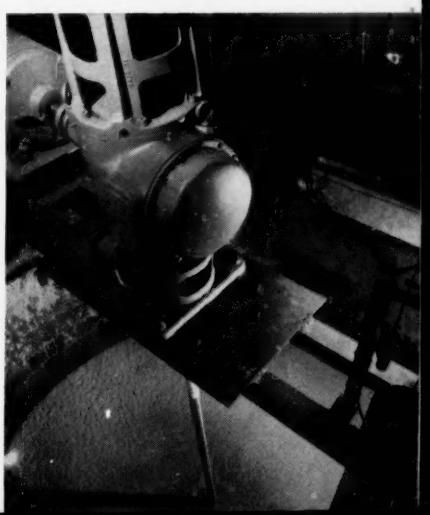
You're sure about *results*, too—because your LIGHTNINs are selected on the basis of application and test data unique in industry. Many thousands of pilot runs, plus scientific methods of scale-up, insure predictable mixing results that are unconditionally guaranteed.

For quick, competent help in getting a new process started right, or in making an old process more efficient, call your LIGHTNIN Mixer representative. He's listed in Chemical Engineering Catalog. Or write us direct.

Lightnin® Mixers

MIXCO fluid mixing specialists

YOU CAN HANDLE any fluid mixing job, in tanks of any size or shape, with LIGHTNIN Mixers. Results are fully predictable; unconditionally guaranteed.



FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 128-a Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.